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COLLEGE OF ARCITECTURAL AND CIVIL ENGINEERING

THE PRACTICE AND CHALLENGES OF COST ESTIMATION IN BUILDING CONSTRUCTION PROJECTS IN ETHIOPIA: CASE STUDY OF FOUR GRADE ONE CONTRACTORS

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A Thesis Submitted to College of Architectural and civil Engineering in partial Fulfillment of the Requirement of Master of Science in Civil Engineering (Construction Technology and Management).

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APPROVAL PAGE

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CONFIDENTIALITY OF RESEARCHING SUBJECT

The researcher of this thesis has agreed that all project names and the case study company's name will be kept confidential. This has been made possible by replacing the performing company names as well as project names with anonymous names. The information gathered during this study is under the sole ownership of the researcher, and access to the information has been limited to the researcher and the supervisor.

ABSTRACT

Cost estimating is the compilation and analysis of many items that influence and contribute to the cost of a project. Mainly emanating from the various variables involved and the forecasting needed, producing accurate cost estimation faces different challenges. The objective of this research is to explore the cost estimation practices and gain an understanding of factors that are the challenge and problem areas of cost estimation in building construction projects and to recommend possible improvement solutions. This was achieved through case study of four grade one contractors of which five projects selected from each contractor to review the cost estimate practice. Accordingly, the research examined case projects' cost records, cost analysis documents and contract documents. In addition, interviews and discussions are used to substantiate as well as support the findings of the document analysis to ensure the validity and reliability of the information.

The findings of the study indicate that contractors predominantly undertake cost estimating for planning tender and for new variation works at execution stage. Detail estimating technique is widely applicable and contractors have not adopted estimating tools that consider risks and variability in cost estimates. The study revealed that the major challenge of cost estimation continues to be lack of sufficient project information at time of tender, poor project specific assessment, poor analysis of construction costs especially in estimating risk and indirect costs and influence of fierce competition in the industry.

Key words: Cost estimation, estimating techniques, construction costs, challenges of estimating

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ABBREVATION

AACE	Association for the Advancement of Cost Engineering
BOQ	Bill of Quantities
CIF	Cost Insurance and Freight
CSA	Central Statistics Agency
EBCA	Ethiopian Building Construction Authority
ECCA	Ethiopian Construction Contractors Association
ETCA	Ethiopian Transport Construction Authority
FIDIC	Fédération International des Ingénieurs Conseils
FOB	Free on Board
GDP	Gross Domestic Product
HS	Harmonized System
IMF	International Monetary Fund
MoFED	Ministry of Finance and Economic Development
PPA	Public Procurement Agency
VAT	Value Added Tax

CHAPTER ONE: INTRODUCTION

1.1 The Research Background

The construction industry plays significant role in the growth of any economy. Particularly in many developing countries, major construction activities account for about 80% of the total capital assets Lioyd (1987) Cited in (Wubshet, 2004). Moreover, in these countries, construction accounts for 10% of their GDP and more than 50% of the wealth invested on fixed assets. In addition to that, the industry provides high employment opportunities, probably only second to agriculture Ofori (2006) cited by (Abadir, 2011). Similarly, in Ethiopia, public construction projects shared an average annual rate of 58.2% of the capital budget between years 1997/98 and 2001/02 (Wubshet, 2004). Moreover, construction industry accounted for 4%-7.6% of the total GDP of the country between years 2010/11- 2013/14 (MoFED, 2014). In the reflection, the industry's national figure shows that the construction industry plays great role in Ethiopian economic development.

Despite construction industry's significant contribution to the economy of developing countries and the critical role it plays (in the development) of the nations, the required level of performance of the industry remains generally low. In this regard, many projects exhibit cost overruns, time extensions, and fail to realize their intended benefit or even from the fact that totally terminated and abandoned before or after their completion due to conflicts among parties Idoko (2008) cited by (Abadir,2011). In general construction, industry in developing countries fail to meet the expectation of the government, client and society as a whole (Wubshet, 2004).

Problems of cost estimation in the construction sector is one of the contributing factors of poor performance. As Ahuja (1994) stated estimating is the primary function of the construction industry and thus accuracy of cost estimates starting from early phase of a project through tender estimate can affect the success or failure of any construction project. However, the industry is known for having poor price forecasting and cost estimating practices. The poor cost estimating practices like poor analysis of cost data, lack of knowledge in the construction process by estimator, poor document analysis and so on, generally lead to poor overall project performance. In general, they lead to over budget completion, delays or even compromise of potential benefits of project's products. Moreover, construction contractors have to produce

accurate cost estimates as overestimated or under estimated costs has potential to cause missing strategic opportunities to construction contractors (Akintoye, 2000).

1.2 Problem Statement

The construction industry in Ethiopia shares many of the problems and challenges its counterparts in other developing countries face, perhaps with greater severity. In terms of cost estimating, the potential problems associated with the practice of cost estimation in building construction projects originate from the following major issues:

1.2.1 Estimating Method in Practice

In this regard, in the international construction context, according to Akintoye and Fitzgerald (2000), the standard estimating method is deterministic (single point number) in its nature. However, this approach generally fails to cope up with the realities of today's world cost as it involves a high risk of overestimating or underestimating. In relation to this, despite the suggestions different studies on the process and principals involved in costing such as Law (1994) and Stewart (1995); Carr (1989) pointed out that there is serious lack of commonly accepted estimating guidelines. Even the existing and being practiced techniques are inaccurate and unstructured and are solely based on contractors' own experiences and applying purpose procedures stated by the software systems.

In Ethiopian context, previous studies by Tadesse (2006) and Abeselom (2008) show that there is a wide application of detailed estimating technique similar to this suggested by the literature, in construction industry. However, like the international practices, it can be argued that they are subjected to the flaws and drawbacks of the international practices discussed in the above paragraph. Therefore, this research aimed to investigate the key drawbacks of the cost estimation practices of the industry. Indeed, this thesis mainly focuses on investigating the challenges and problem areas of the current cost estimation practice of Ethiopian contractors-one of which could be the method adopted.

1.2.2 Information on Cost Estimating Items

The use of accurate data for direct cost components make crucial component of an appropriate cost for construction project. The quality of these estimates, measured by consistency between estimated and actual values, is directly proportional to certainty of the direct costs the components of the cost item that the practitioner has as its disposal. Information on material costs, equipment costs and labor costs are highly important to determine the direct costs of the project. However, research by Asteway (2008) indicated that data sources published by Central Statistics Agency (CSA) and Ethiopian Construction Contractors Association (ECCA) are not widely used by most contractors. One of the reasons could be the price data by these institutes are published in a very wide range of time, while the price of materials on the market changes within very short time. In light of these, it can be argued that there are no established systems, which provide contractors up to date data of cost of resources.

Another critical data for cost estimation is crew productivity, which is an important component of a cost breakdown structure. In this regard, for example, the Ethiopian Building Construction Authority (EBCA) and the Ethiopian Transport Construction Authority (ETCA) have developed material consumption breakdowns and performance standards for the most commonly used activities for building and road projects respectively (Tadesse, 2006). However, due to the advancement of construction technology, change in capacity and productivity of construction equipment and change in skill of construction labor from time to time; the performance standards get outdated. Therefore, this problem is also reflected in Ethiopia context, as estimators do not have access to up to date productivity norms that can be applied industry wide.

1.2.3 Stability of Market Conditions

Cost estimating, in essence, involves forecasting of prices. Cost estimates for construction work are produced at specific point in time and the prices used therein are relevant only for that time and for short near future. This is because prices for goods supplied and work undertaken are continually subject to market forces. In recent years in Ethiopia, the price of materials on market observed to be very unstable. Consequently, price of construction commodities greatly increased and still increasing. According to IMF (2008), the inflation rate in Ethiopia was 40%. The construction sector is one of the victims of this high price rise of inputs persists in Ethiopia.

In this regard, a study made by Fetene (2008) indicated that inflation or increase on the cost of construction materials is the major causes of cost overrun for public building projects in Ethiopia. This research also revealed that the price of materials used to exhibit a very high increase that is, more than 34%.

In a related issue, a study by Asteway (2008) indicated that the degree of predictability of material price variation is very low compared to the price fluctuation of labor and equipment, which can be fairly predictable taking in to consideration of other factors.

Therefore, in general, market predictability is one of the key issues in cost estimating conducted for future consumptions. Given the volatility of the Ethiopian market, the accuracy and forecasting capability of the estimating could be seriously affected by the market.

1.2.4 Others

In addition to the above, clearly defined scope of works and specifications, well-established quantities, etc also make a critical component of cost estimates as they affect the methodologies employed and ultimately the cost estimates. However, in this regard, the construction industry in Ethiopia known for issuing incomplete drawings, ambiguous specifications and incomplete scope definitions (Abeselom, 2008).

1.3 Research Questions

Based on the discussed problems above, the research questions raised by the study are:

- What are the cost estimation practices by the subject contractors and how are these practices compared and contrasted to the accepted international practices and principles?
- What are the major challenges and problems in the current cost estimation practices of the Ethiopian construction industry as exemplified by the subject contractors?
- What approaches can improve the problems related to inaccurate estimates?

1.4 Objective of the research

1.4.1 General objectives

The main purpose of this research is to explore and identify the key characteristics of the cost estimating practices of building projects in Ethiopia and identify the major factors affecting the practice with an objective of suggesting ways of alleviating these challenges and thereby improving the accuracies of cost estimates.

1.4.2 Specific objectives

With the above overarching aims, the study specifically set the following objectives

- Explore the current cost estimating practices by the selected case contractors and identify the gaps in current practice of cost estimation as compared to accepted practices
- Identify the major challenges and problems faced by the selected contractors in their cost estimation practices
- Recommend possible ways of alleviating these challenges for improved cost estimating practices

1.5 Significance of the Study

The finding of this research has pin pointed gaps on the current practice of cost estimation and the major variables affecting the cost estimation process of building projects. Its ultimate significance is to contribute towards a more accurate cost estimation practice by exploring the deficiencies of the existing practices and suggesting 'best practice based' cost estimating practices as well as exploring for ways of alienating the major challenges of the currently exercised practices.

1.6 Scope of the Research

From the manageability point of view, the research scope is limited to the investigation and analysis of gaps in the current practice and the major problems affecting the cost estimation of building construction projects. Construction projects undertaken by contractors range from light residential buildings to complex and heavy projects. However, the scope of this research work is limited and focused on building construction projects. The need for limiting the scope to building construction projects arises mainly due to the fact that building projects are the most common projects local contractors involve. This research paper is not expected to come up with a report that covers vast construction industry of Ethiopia due to limited budget and time. Therefore, this study attempted to investigate selected contractors as a sample for the case study.

1.7 Limitation

This research could not evaluate the accuracy of the cost estimates due to lack of data on the actual cost records by contractors. Strategic feedback systems are an essential part of reviewing, assessing, and improving the data available so that the new estimates do not have inaccuracies carried forward from previous projects. This is, ideally, a process of learning from mistakes, and seems to be a process neglected by estimators and their companies when it comes to improving the accuracy of the estimating practice.

1.8 Over view of the study

This section presents the organization of this report. As also preselected on float in Figure 1.1, the research report has five chapters.

Chapter One- Presents a background to the research and serotypes the research problem. It also presents the key research questions formulated, the aims and objectives of the research. The chapter also presents the description of the major limitations of the study and the scope of the study and its applicability.

Chapter Two- Presents the literature review. It presents both the contemporary theoretical views of cost estimation as wells as empirical findings of the researches carried on the issue. It highlights the basics of cost estimating and the drawbacks of the contemporary cost estimating practices. The chapter also identifies the major factors that the literatures identify as the factors that affect the construction cost estimates.

Chapter Three-Describes and argues for the methodology as well as the methods adopted by the study. It critically stereotypes the research philosophy, the research methodology and discusses the data collection process and analysis techniques adopted by the research.

Chapter Four-Presents the discussions and findings of the study. The findings are presented based on themes selected around the topics stereotyped from literature review.

Chapter Five-Draws the conclusion of the research and provides recommendation on the improvement of the practice.

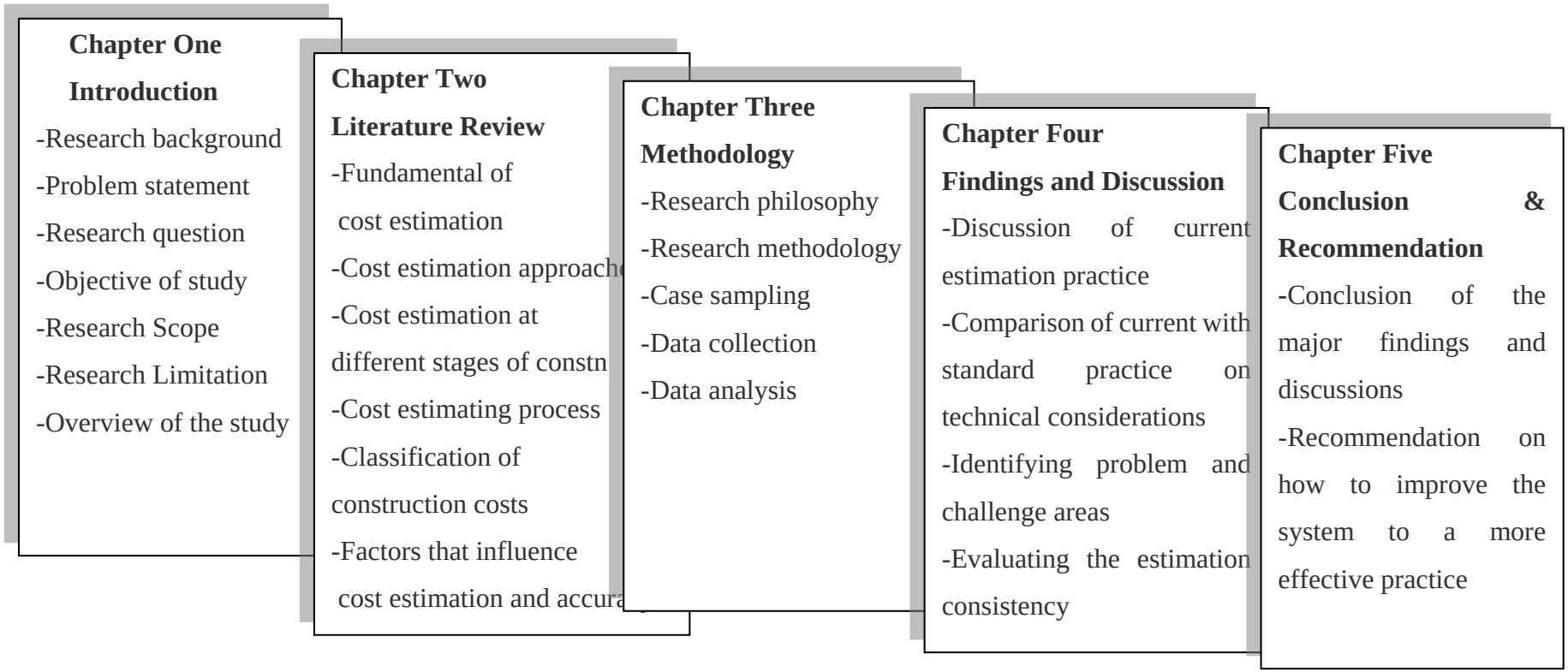

Figure 1: 1 Structure of the study report

CHAPTER TWO: LITRATURE REVIEW

2.1 Introduction

This chapter provides aspects of study in terms of theoretical concepts and the reflection on what has been already published on a topic by other researchers and scholars. The key points identified in the literatures are basic concepts of cost estimation, the approaches of cost estimation, cost estimating at different phases of construction, classification of cost estimates, the steps in developing an estimate and components of construction costs. This chapter also addresses empirical findings on the factors that influence project cost estimation and its accuracy.

2.2 Fundamentals of Cost Estimation Theory

2.2.1 Definitions

The Project Management Institute (PMI, 2004) and the Association for the Advancement of Cost Engineering (AACE, 2007) define construction cost estimation as process whereby construction projects predict costs of expenditure of resources necessary to realize the intended project which lays base for feasibility study, tender price of construction contracts, cost control and project management. In the reflection, this show that both literatures have indicated similar concepts on the construction cost estimation theory. This explanation is exactly implemented in Ethiopian construction industry cost estimation concepts in everywhere as the world has similar nature.

The code of estimating practice produced by the chartered institute of building (CIOB, 1997) defines estimating as ‘the technical process of predicting costs of construction’ and tendering as ‘separate and subsequent commercial function based up on the estimate’. Ashworth and Skitmore (1983) and Smith (1995) argue that estimating cannot be a precise technical and analytical process but it is largely a subjective process. In relation to this Elhag, Holm and *et al*. (2005), argue that it is an experience-based process, which involves evaluations of unknown circumstances and complex relationships of cost-influencing factors.

In the reflection the literatures show the predictive nature of cost estimate and its importance in the determination, control and overall management of cost control. Cost estimating is a process of analyzing a specific scope of work and predicting the cost of performing the work. That involves collecting, analyzing and summarizing all available data related to a building

construction project. This is apart from those variable items such as production rates, material usage or other historical cost data derived from the company's files as Cited by (Akintoye, 2000).

2.3 Cost Estimating Approach in Construction Industry

Assael (1985) and Kotler (1988) as cited by Akintoye *et al*. (1992) classified pricing strategies as cost oriented, competition oriented and demand oriented. Cost-oriented methods consider cost plus mark-up, breakeven and target rate of return where as competition-oriented method focus on pricing based on competitors' prices. This approach involves pricing in relation to competitors' expected reactions. Demand-oriented pricing is based mainly on the going price or customers' perceived value.

On the other hand, Gabor (1977) also Cited by Akintoye *et al*. (1992) classified pricing into two basic groups cost based and market-oriented pricing and argues that other approaches fall in between. Cost-based pricing encompasses profit-oriented and government-controlled prices, while market-oriented pricing includes customer- and competition-oriented pricing.

Mochtar and Arditi (2000) indicated that cost based pricing approach involves estimating the project cost then applying a markup for profit whereas market based pricing strategy is basically the inverse of cost based pricing. It starts with the customer and the benefits the product creates relative to key competitors. Based up on a combination of customer benefits, price is set in the market. This is mostly developed in manufacturing industry and beyond the scope of this study. Mochtar and Arditi (2000) also pointed that cost based pricing approach is the most practiced approach in the construction industry though market based pricing strategy is becoming the future alternative for pricing in the industry. The above discussions indicate various pricing methods and this research focus on the cost based pricing approach. The next sections present cost estimating methods and estimating process followed at different phases of construction.

2.4 Cost Estimation at Different Phases of Construction

The project cost management includes three core processes: cost estimation, cost budgeting and cost control (PMI, 2004). Cost estimation at the planning stage plays a vital role as it influences the decision making process from early planning to final project outcomes.

At conceptual stage of the project, clients need an estimate of the probable cost of the construction to access the financial feasibility of projects. To satisfy this need at a stage when major features of the project have not been established yet, cost estimators use preliminary estimate to establish the budget. Parametric cost estimation or estimation based on historic database is widely used in developed countries to satisfy this need. However, Sodikov (2005) states that developing countries face difficulties in relation to the creation of a costs database, which may be used for cost estimation in either at the conceptual stage or at the feasibility study of the project cycle.

As design completed, a final pre- bid estimate can be compiled to anticipate the contractors' bid price for the project. This estimate is relatively accurate and can be used to check whether the bid prices established will be within the owner's budget for planned project.

Akintoye and Fitzgerald (2000) indicated that contractors undertake cost estimating, predominantly for construction planning purposes including the preparation of tenders, cost control of projects during the execution stage and to lesser extent for construction projects evaluation. At tender stage, contractors determine project direct costs and below the lower cost, it would not be economical to carry out the works. In addition, once construction is underway, this estimate provides benchmark for the contractor to identify deficiencies and helps to take corrective actions to maintain profit margins.

In cost control programs, estimating is required to facilitate the control of expenditure of funds for the project. Contractors set cost targets based on their estimates of the cost of each component of the work, and then they compare the actual cost of work against these target amounts to find out if corrective action is required to bring productivity up to required levels. Often during construction operations, the owner or the designer asks the contractor to quote prices for proposed changes in the scope of the work (Pratt, 2011).

2.5 Classification of Cost Estimate in Construction Projects

The Association for the Advancement of Cost Engineering International (ACCE,1997) recommended practice suggests that the most significant factors for classifying the cost estimates are the level of project definition, end usage of the estimate, estimate methodology, and effort and time needed to prepare the estimate. The guideline developed by AACE uses the level of project definition as the "primary" characteristics for classifying cost estimate, the end use of estimate and estimating methodology as the "secondary'' characteristics for classifying estimates.

As observed from Table 2.1, the five estimating categories labeled from class 1 to class 5. In this regard, class 1 being the most accurate estimate requiring high effort; while class 5 is least accurate demanding less effort to produce estimates. The level of project information required increases as the estimate changes from class 5 to class 1.The methodology applied also changes from judgmental [1] or stochastic[2] for class 5 estimate to completely deterministic[3] method for class 1 estimate. This is because at class 5, the level of information available is limited, thereby leading itself to only judgmental or stochastic estimating process. As level of project definition increases, the estimating methodology moves from the stochastic process to the deterministic process. This shows that the relative accuracy of estimates denoted by level of project definition.

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[1] Judgmental process refers to a non-quantitative process whereby conclusions and decisions are made based on the experiences and opinions of the decision makers

[2] Stochastic process, also refers to as non-probabilistic process, is a process whereby at least one of the input to the stochastic model is uncertain and subject to variation

[3] Deterministic process refers to the process whereby all the inputs to the deterministic model are known and cannot vary

Table 2: 1 AACE Generic cost estimating classification matrix

	Primary Characteristics	**Secondary Characteristics**			
Estimate class	Level of project definition Expresses as % of complete definition	End usage Typical purpose of estimate	Methodology Typical estimating methodology	Expected accuracy range Typical variation in low and high ranges[a]	Preparation effort Typical degree of effort [b]
Class 5	0%-2%	Screening or feasibility	Stochastic or judgment	L:-20% to -50% H:+30% to +100%	1
Class 4	1%-15%	Concept study or feasibility	Preliminary Stochastic	L:-15% to -30% H:+20% to +50%	2 to 4
Class 3	10%-40%	Budget, authorization or control	Mixed but preliminarily Stochastic	L:-10% to -20% H:+10% to +30%	3 to 10
Class 2	30%-70%	Control or Bid/tender	Preliminarily deterministic	L:-5% to -15% H:+5% to +20%	5 to 20
Class 1	50%-100%	Check estimate or Bid/tender	deterministic	L:-3% to -10% H:+3% to +15%	10 to 100

Notes: [a] The availability of applicable reference cost data can affect the range markedly

[b] If the range index value of "1" represents the 0.005% of project cost, then an index value of 100 represents 0.5%

Estimate preparation is highly dependent upon the size of the project and the quality of the estimating data.

Adapted from (AACE 1997)

2.6 The Cost Estimating Process

The cost estimating process requires tools that must be available or collected to perform the estimating function. An organization that is embarking on an estimating mission needs to identify, collect, organize and activate the listed principal estimating principles summarized here under by (Steward 1995).

- Information-which includes historical data or recent information on similar work, professional and reference materials (books, magazines, presentations, and reports), knowledge of the operation, and the results of market and industrial surveys
- Methods- which includes techniques, procedures, policies, and practices discussed previously
- Plan /schedule for estimating
- Skills which includes knowledge regarding finance, engineering and technical skills

According to Uman (1990), factors like extreme diversity in building systems, methods, projects, suppliers, contractors and workforce makes it difficult to develop standard process of cost estimating. However, (Steward 1995) listed twelve basic steps to be followed in cost estimation summarized here under,

Step one: Developing ground rules and assumptions

Step two: Schedule the work elements

Step three: Retrieve and organize historical data

Step four: Develop and use cost-estimating relationships

Step five: Develop and use production learning curves

Step six: Identify skill categories, skill levels and labor rates

Step seven: Develop labor hour and material estimates

Step eight: Develop overhead and administrative costs

Step nine: Apply inflation and escalation factors (cost growth factors)

Step ten: Price or compute estimated costs

Step eleven: Analyze, adjust and support estimate

Step twelve: Publish and present the estimate so that it can be utilized effectively

2.7 Components of Construction Costs

The construction cost has two parts; the direct and indirect construction costs which are briefly elaborated below.

2.7.1 Direct Construction Costs

Direct construction cost consists physically traceable to the costs needed to carry out a specific, well-defined item of work. The direct cost components listed as,

- Material cost
- Labor cost
- Equipment and
- Subcontractor cost (if employed)

2.7.1.1 Material cost

According to Chitkara (2001), the direct material cost generally includes:

- Purchase costs, ex-factory or specified delivery location.
- Transportation costs, custom clearance, insurance and handling charges until arrival at site.
- Site manufacturing and fabrication costs to transform raw materials in to products for use in permanent works

The material cost includes not only the direct costs of material but also any other costs that may be obtained except labor and equipment for installation. Additional items considered are transportation, freight costs, delivery, storage, sales, other taxes and losses.

Material Unit Cost=Σ (Material quantity x Materials unit price) ……. (2.1)

Material quantity is obtained from consumption standard which is the material quantity required to execute specific activity including the assumed allowances for wastage. Material unit price can be obtained from suppliers from various sources, including, but not limited to, catalogs, vendor price sheets and/or vendor quotations, pricing services, cost data books, historical records and other resources.

For materials to be supplied from local market or produced on site the material unit cost can be easily computed by adding an extra cost of loading, unloading and transportation costs to the project on the supplier's invoice. However, if the material is imported from abroad, the estimator should have proper understanding of the logistics of imported materials; international

commercial terms and should compute these additional costs and add to the supplier's price to get the material unit price to the project site (Tadesse, 2006).

2.7.1.2 Direct Labor Cost

Labor cost consists of the cost of employees directly or indirectly involved depending on the extent of their relationship on the project. Direct labor cost considered as all costs related to the workers working on specific activity such as carpenters, masons, erectors, painters, plumbers and miscellaneous workers. Whereas indirect labor costs cover all the salaries and benefits of staffs other than senior management members working at the head office and staffs not included at the site management members depending on the size, type and organizational structure of the construction project (Tadesse,2006).

Some examples of indirect labor cost at head office could be the salaries and benefits of technical, administrative, marketing, finance, supply staffs…whereas indirect labor cost at project site could be the salaries and benefits of site engineers, office engineers, administrative and finance staffs, data collectors and so on. Indirect labor costs are accounted in overhead costs.

For calculating the direct labor crew required for one activity, the cost estimator shall determine the number of labor, skill and utilization factor (UF) required for executing the construction work.

Direct labor hourly cost=Σ (No of labor x Basic salary x Labor index x UF) …... (2.2)

Direct labor cost = Direct labor hourly cost / Hourly crew productivity…... (2.3)

i. Determination of Number of Labor

The number of direct labor required for an activity varies based on the number of crew deployed, the job schedule, and the site condition, the intensity of the activity, the number and type of equipment involved. Clough (2015) claims that labor is both the largest component of cost within an estimate and at the same time the most difficult and therefore the most risky-to-estimate component of construction cost. The literature Clough (2015) suggests that the under listed steps to determine the number of work force required for the job,

1. **Building the job in mind**-the estimator will determine all of the activities that must be performed in order to complete the work. Activities defined as elements of work that are identifiable and quantifiable and consume resources.
2. **Creating work breakdown structure**
3. **Determining, literally estimating, the number of person**-hours necessary for the crew and each of its craft workers to complete every activity that are identified. This component of the labor estimate is both vital and, at the same time filled with uncertainty.

ii. Determination of Crew Productivity, Utilization Factor and Labor Index

To accomplish the prediction of crew productivity, the best approach is to use historical cost information that contractors' cost estimating, cost accounting, and cost control systems developed. This is in fact; the very reason for the contractors' compiling and maintaining information files. The historical cost data is tabulation of contractors' costs of performing work, by project and by activity, on previous projects. This information generated as each project performed, and is stored in a systematic manner in historical cost database. This database is one of the contractor's most important and most closely guarded assets (Clough 2015). Thus the amount of crew can be obtained from previous experience of works similar in nature, historical data, national /international performance standards and other trial tests conducted on actual conditions. The utilization factor (UF) is used for calculating the contribution of a crewmember for the specific activity who can also be engaged in other or more other activities.

In Ethiopian context, according to proclamation No.377/2003, the minimum employee benefits that the cost estimator should include in determining the labor index listed as;

- Severance pay
- Annual leave
- Occupational accident expenses
- Occupational disease expenses
- Overtime pay
- Occupational safety
- Health and working environment and other benefits resulting from collective agreements.

2.7.1.3 Equipment Costs

The equipment cost like labor costs, are difficult to evaluate the exactness of the values. Equipment accounts for a substantial proportion of the total cost of most construction projects. However, is typically somewhat less significant as a fraction of the total cost in building construction work (Clough 2015). Many factors can influence the selection of equipment on a construction site. These factors can be group into three categories: site conditions, the nature of the work, and equipment characteristics.

Equipment production rates, like labor production rates, are subjected to considerable variation, and influenced by host of different jobsite conditions. There are several sources of equipment production information like production information provided by manufacturers', contractors' historical records and experiences of operators'/machine owners'. The most reliable by far are the contractor's production records from past projects. Additionally, input from the equipment operators can be very useful at times. If a new piece of equipment is involved, with which there is no prior experience, production information provided by the equipment manufacturer or dealer can be useful.

Equipment costs are generally divided into two categories: ownership costs and operating costs, as discussed below. According to Tadesse (2006), in addition to owning and operating costs of equipment, the equipment owner's overhead costs should be included to determine the overall equipment hourly costs.

i.Equipment Owning Cost

Equipment ownership costs defined as costs that continue to accrue, whether the machine is in use or not. Examples include financing costs for buying the machine (or sinking fund contributions for replacing the machine at the end of its useful life) and depreciation.

Equipment owning cost includes depreciation cost, insurance charges, property tax, erection and installation cost, major repairs and overhauls (Clough 2015; Tadesse 2006).

ii.Equipment Operating Cost

Equipment Operating costs, as their name indicates, include costs associated with the operation of the machine. Operating cost accrue only when the unit of equipment is used, whereas ownership costs accrue whether or not the equipment is used. Equipment operating cost

includes fuel cost, cost of lube oils, filters, and grease cost of tires, cost of under carriage (in case of crawl-mounted equipment), cost of normal repairs and cost of high wear items.
To get the hourly cost of operator, the annual equipment operator's salary and benefits summed up and divided by the annual utilization of equipment (Clough 2015; Tadesse 2006).

2.7.1.4 Subcontract Costs

All tasks in given construction project undertaken by general contractors may not be completed entirely by contractor's own workforce. Therefore, subcontractors engaged to accomplish the jobs. The cost estimator should delineate the work items to handle by subcontractors, obtain price quotes from various subcontractors and then factor selected prices into the cost estimate. The cost estimator must also determine any administrative responsibilities and interference or scheduling problems involved in subcontracted work. That will increase the cost of the general contractor's work items (Steward 1995).
When specific activities are subcontracted to subcontractors, the subcontract prices considered as the direct cost of the activity (Tadesse, 2006).

2.7.2 Indirect Construction Costs

Indirect construction costs include all costs, which cannot be directly booked under the specific activity but required to keep the whole project operational (Asteway, 2008). According to Chitkara (2001), the range of indirect costs ranges from seven to thirty-five percent (7% - 35%) of the total cost depending up on the nature of the project. Indirect costs subdivided into two categories: project overhead and office overhead costs. Project overhead costs also referred as general conditions costs, or as project indirect. Office overhead costs also referred as company overhead, or as general overhead (Clough 2015).

2.7.2.1 Project overhead costs

Project overhead costs, as the name implies, refer to overhead costs incurred on job site. These costs typically significant items of expense on project and will generally contribute from five to fifteen percent (5% -15%) of the total project cost, depending on where and how certain project costs are included in the cost estimate (Clough 2015). Project overhead costs estimated with reasonable accuracy, compiled and included in the estimate by the estimator. Project overhead costs computed by listing and costing each item of overhead individually, rather than by using an arbitrary percentage of project cost. This is true because different projects can and

do have widely varying job overhead requirements. The only way to arrive at an accurate estimate of job overhead is to analyze the particular needs of each project and determining the cost (Clough 2015). These project overhead costs for a project determined by direct estimation. More typically, however, these costs extracted from the contractor's historical cost database and are then included in the estimate.

2.7.2.2 General overhead

General overhead or office overhead includes general business expenses such as cost of owning or leasing the contractor's head office and salaries of the head office employees. The head office staff include but not limited to company president, estimators, cost accountants, reception and clerical workers, and so on; utilities and equipment for the home office; insurance; office supplies; furniture; regular legal expenses; travel; donations; advertising; association dues; and unnamed elements. Some companies include the salaries of project manager's in the category of general overhead. The total cost of this overhead expense generally ranges from three to ten percent (3% to 10 %) of contractor's annual business volume (Clough 2015).

2.7.3 Risk Allowances

Al-Bahar (1990), defines risk as the exposure to the chance of occurrences of events adversely or favorably affecting project objectives because of uncertainty. Some of the risk conditions that estimator need to consider includes the following (Plither, 1992),

- ability of the contractor to manage the productivity of resources that was assumed during the estimation
- bad weather and the interference with production and program that it may cause
- the availability of materials for incorporation in the work
- delays due to industrial disputes
- the financial stability of the client and
- the performance of equipment

Contingency is the amount of money added to an estimate to cover unforeseen needs of the project, construction difficulties or estimating accuracy. In estimating, the word contingency used for two types of estimates. The first is the expected value of possible identified event. The second type of contingency is the possible cost of unforeseen events. Those events impossible to identify because the engineer does not know what can happen in the future. The second type

is a true contingency and the one that needs close attention, because it is margin for error (Carr, 1988).

In Ethiopian context, there is practice of considering ten percent (10%) of the total project cost as the contingency. Most of the time consultants compute this margin to secure project budget. Ostwald (2001) identified the main items that make many estimators add a contingency to the estimate to cover one or possibly more of the following:

- Unpredictable price escalation for materials, labor, and installed equipment for projects with an estimated duration greater than 12 months
- Project complexity
- Incomplete working drawings at the time detail estimate is performed
- Incomplete design in the fast-track or design-build contracting approach
- Soft spots in the detail estimate due to possible estimating errors, to balance an estimate that is biased low
- Abnormal construction methods and startup requirements;
- Estimator personal concerns regarding project, unusual construction risk, and difficulties to build and
- Unforeseen safety and environmental requirements

The following methods and models proposed for dealing with risks and uncertainties. Some of them are Simple assessment, Sensitivity analysis method, Probability analysis method, the Monte Carlo simulation method, Decision tree analysis method, multiple estimating using risk analysis, Bayesian belief networks'. Generally, these models characterized by their complexity and high mathematical treatment and thus difficulty for application (Khalafallah, 2002).

However, Tadesse (2006) proposed for the contractor to trace the local and international market trends and to use the changes in price index in calculation of economic risks as:

RA= (DMCI* DMC) + (DLCI* DLC) + (DECI* DEC) + (SOCI +SOC) + (HOCI* HOC)

Where, RA=Risk allowance

DMCI=Direct material cost increment	DMC=Direct material cost
DLCI=Direct material cost increment	DLC=Direct labor cost
DECI=Direct equipment cost increment	DEC=Direct equipment cost
SOCI=Site overhead cost increment	SOC=site overhead cost
HOCI=Head office overhead cost increment	HOC=Head office overhead cost

Consumer price index could be used as a base for estimating risk allowances, though the consumer price index published by Central Statistics Agency, database has got shortcomings listed under here (Tadesse, 2006).

- Construction materials categorized under the same group with house rent, fuel and power.
- All types of construction materials grouped under one category whereas the rate of price increment for construction materials widely vary depending on the type of materials.
- Locally produced construction materials and imported construction materials treated under the same group of consumer price index.
- Governmentally controlled material prices grouped with market oriented material prices such as fuel as compared to cement.
- Moreover, the published consumer price index does not include construction labor and construction equipment.

Due to the above facts, it would be difficult to apply the price index for risk analysis.

2.7.4 Profit

Profit is the sum of money that will remain with the contractor after the project is completed and once the costs of carrying out the works paid for (Plither, 1992).

2.8 Factors that Influence Project Cost Estimation

Construction is multidisciplinary industry and its work involves many actors that has its own influencing factors on the cost estimation. Akinci and Fischer (1998), Akintoye (2000) and Liu and Zhu (2007), revealed that a large number of factors affect or influence cost estimation. In general, they assert that these factors directly related to construction project specific factors, the construction organizations' responsibilities for managing costs, economic and external conditions as well as the technological and political environments within which they operate.

Akinci and Fischer (1998), separated factors affecting cost estimates of project from those affecting final cost of projects. The factors that affect cost estimates related to estimator-specific factors and design and project specific factors. Estimator specific factors are risks associated with estimator's background and experience and as well as cognitive bias and error occurrence. While design and project-specific factors are those factors related to project size, type of project, ground conditions, type of client, material costs, likely design and scope changes, duration,

tendering method and contract type. On the other hand, factors that affect the final cost and increase the gap between the actual cost and the estimated cost of a project are related to construction specific factors and as well economic and political environment-specific factors as cited by (Abukar, 2006).

Similarly, Akintoye (2000) presents twenty-four variables that affect the project cost estimation and he grouped them in seven factors with the most important being project complexity followed by technological requirements, project information, project team requirement, contract requirement, project duration and finally market requirement. The finding also indicated that construction firms, irrespective of company size, generally have similar opinions regarding the factors influencing construction cost estimates.

In the same manner Liu and Zhu (2007), categorize the factors that influence the cost of project as control factors and idiosyncratic factors. Control factors are those determined by the estimators to increase the performance of the estimation. Idiosyncratic factors are the factors that affect estimation but are outside the control of the estimator. This includes but not limited to market conditions, project complexity, weather, type of contract, type of client, site constraints and resource availability. By aggregating many factors influencing construction costs Abukar (2006), grouped the factors in to four (discussed in table 2:3) as Project specific factors, client and contractor related factors, competition and market conditions, and Macroeconomic and political factors.

As presented on above literatures, there are several influencing factors, but it is difficult to find detailed study regarding the challenges of cost estimation in building projects in the Ethiopian construction industry as prior research. However, related studies by some researchers Tadesse (2006) and Abeselom (2008) are reviewed in this research.

Tadesse (2006) claims that there is lack of competency in estimating and lack of organized data base system in the industry. According to the literature, many contractors use previously prepared unit prices by other contractors that they believe are well-organized contractors without justification of the cost components included in these unit prices.

Further, the same literature elaborates contractors expected to satisfy high quality and shorter time requirements of project owners. Of course, the contractor still has to offer the lowest possible construction cost to win the bid. Thus in prevailing unfair market competition, there is high tendency of under estimation to stay in business.

Abeselom (2008), identified major factors affecting the accuracy of contractors cost estimates as,

- unfamiliarity with different estimating methods
- lack of up-to-date estimating manuals
- inadequate search for information on project specific and contextual cost and non-cost items,
- improper estimation of overhead costs,
- failures to evaluate and incorporate and/or difficulties in forecasting quantifying risk allowances and
- Inadequate assessment of factors while determining markup amount or profit margin

Table 2: 2 Four groups of factors influencing construction costs

Factors	Factors affecting construction costs: Examples	Layers of determining factors and comments
1.Project specific factors	Project size Project complexity Quality	Mainly client controlled factors but may have favored certain contractor
2.Client& Contractor related factors	Contractor type Client type (e.g. public, private) Procurement method Contractor-client relationship	Both client and contractor could influence indirect cost through supplier structure and extent of relationship
3.Competition and market conditions	Level of competition Level of construction activity	They affect both direct and indirect costs but their impact on the latter is more exacerbated when client /contractor related factors are taking in to considerations
4.Macroeconomic and political factors	Inflation and interest rate General labor market rules and other government regulations	Uncontrolled but predictable factors by either client or contractors

Source: Abstracted from (Abukar 2006)

2.9 Factors Affecting Accuracy of Cost Estimates

The word “accuracy” has two definitions as defined in Webster’s College Dictionary (1999) as:

- The condition or quality of being true, correct, or exact; precision; exactness.
- The extent to which given measurement agrees with the standard value for that measurement

Hicks (1992), states that without an accurate cost estimate, nothing short of an act of God can be done to prevent a loss, regardless of management competence and financial strength of the contractor cited in (Li Liu and Kai Zhu, 2007).

The Construction industry institute (CII, 1998), study highlights the major factors influencing on estimate accuracy:

- Quality and amount of information available for preparing the estimate;
- Time allocated to prepare the estimate;
- Proficiency of estimator and estimating team;
- Tools and techniques used in preparing estimate

Accurate prediction of construction costs is fundamentally dependent on the availability of quality historical cost data and the level of professional expertise among other things. The limited information available at an early stage of construction project may mean that the quantity surveyor must make assumptions about the design details of project, which may not eventuate as the design, planning, and construction evolve (Li Liu and Kai Zhu, 2007).

Also according to Fetene (2008), the actual site conditions of a project are not usually determined until excavation is completed. Thus, unexpected conditions on sub surface may lead to require fundamental redesign of projects with high expense. In addition to this, changes of site conditions become a problem for machinery and supplies to move in and out of the site, which in turn increase costs.

Vergara and Boyer (1974) on the other hand argue that the precision of estimates depends not only on the method but also on the type of work and the intended use of estimate. They argue that to increase the reliability of estimates, the level of detail involved should be increased up to a limit (optimum level of detail) at which the cost of increased reliability equals the value of the increased reliability. Because of the time and cost constraints associated with this practice

they have advocated a probabilistic approach to cost estimating as cited by (Akintoye & Fitzgerald, 2000).

Shash and Al-Khaldi (1992) elaborate factors affecting the accuracy of cost estimating as financial issues, bidding situations, project characteristics and the estimating process itself. They argue that the accuracy of cost estimate irrespective of size of contractors, mainly affected by the previous experience of the contractor on the type of the project. This factor was followed by anticipated or frequent delays in periodic payments, type and size of contract and project location as cited by (Akintoye & Fitzgerald, 2000).

The study by Al-Harbi *et al*. (1994) as cited in Akintoye & Fitzgerald (2000) listed 12 factors that challenge cost estimators face. The major challenge areas identified in the research are tough competition followed by contract period, incomplete drawings and specification, incomplete project scope definition, unforeseeable changes in material prices, changes in owners' requirements, current workload, errors in judgment, inadequate production time data, lack of historical data for similar jobs and lack of experience in similar projects.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Research Methods

Research methodology refers to the principles and procedures of logical thought processes applied to a scientific investigation while research methods concern with the techniques that are available (for data collection, analysis) and implemented in the research (Fellows, 2007). There are different research methods depending on the research philosophical backgrounds that guide them. The common ones are experiment, survey, case study, ground theory, action research and ethnography. In selecting the right research methodology, one has to consider the purpose of research, nature of research problem to be solved, the type of data needed and researchers' ontological and epistemological assumptions on the research problem.

As can be seen from the previous discussions, the nature of the research problem and the objective of the research, this research demand through scrutiny on the current cost estimation practice. The research approach adopted for the present study confirms to qualitative research through a case study design. Case study is an appropriate research method as it emphasizes detailed contextual analysis of a limited number of events or conditions and their relationships. The method for this research shall be a triangulation from an extensive literature survey review and then followed by a document analysis of the case study of the company's cost estimation practice.

3.2 Case Sampling

3.2.1 Determining Case Design

According to Yin (2003), there are two major types of designs in the case study, single case design and multiple case study design. A single case study design focuses only on one case while in multiple case study design cases should be selected so that they are replicating each other either exact (direct) replications or predictably different (systematic) replications. Some of the rationales for using in single cases is when it represents the critical case in testing well formulated theory, in cases representing an extreme case or unique case, single case is the representative or typical case, revelatory case and in case of longitudinal cases. Whereas the major insight to consider multiple is to follow the replication logic. In this logic each case must be selected as it needs to clarify the predicts similar results or predicts contrasting results but

for predictable reasons (Yin 2003). In this study multiple case design is selected as the subject under scrutiny involves examining the issues raised practice by replication logic.

3.2.2 Techniques for Case Selection

Case study research focuses on a small number of cases that are expected to provide insight into causal relationship across a larger population of the cases. The study samples are selected through purposive (nonrandom) selection procedures (Gerring 2007).

According to Gerring (2007), there are nine case selection techniques: typical, diverse, extreme, deviant, influential, crucial, pathway, most similar, and most different.

As far as this research is concerned, grade one contractors involved in building projects are the cases under study and hence extreme case selection used. Extreme case selection method is appropriate where there exist cases of extreme values on an independent or dependent value of interest.

The decision to select grade one contractors is based on the assumption that they usually take most of the large projects given to local contractors and that they have better database for the study. The case contractors who have wide variability of projects and the ones that are volunteer to provide the data and facilitate the projects that could be studied were selected. Accordingly, four case contractors were selected. To review the cost estimating approaches followed, five building projects from each four case contractor were selected. The selection of these projects made in collaboration with the selected contractors' management to represent major works carried by their company in recent years that could be taken as fair representation of the company's portfolio of the work.

3.3 Data Collection Process

This research aims to determine the challenges and problems of the current cost estimation practice using a case study of selected contractors, and answering the following questions:

- What are the cost estimation practices by the subject contractors and how are these practices compared and contrasted to the accepted international practices and principles?
- What are the major challenges and problems in the current cost estimation practices of the Ethiopian construction industry as exemplified by the subject contractors?
- What approaches can improve the problems related to inaccurate estimates?

To answer these questions, document analysis of the case study company's cost breakdown analysis, cost records, contract documents and bill of quantities are conducted.

In addition, interviews and discussions with contractors on the issues that cannot be covered tangibly are covered. The interviews and discussions are used to substantiate as well as support the findings of the document analysis to ensure the validity and reliability of the information.

In addition, the research questions that have been prepared to monitor the attainment of the objectives are used as a guideline for interviews.

3.4 Data Analysis

According to Miles (1994), the qualitative data analysis consists of three concurrent flows of activity; data reduction, data display and finally conclusion drawing or verification.

Data reduction refers to the process of selecting, focusing, simplifying, abstracting, and transforming the data that appear in written up field notes or transcriptions. The data reduction occurs continuously throughout the life of any qualitatively oriented project.

After these data are reduced, the next step of analysis is to change these data in to a data display form. A display is an organized, compressed assembly of information that permits conclusion drawing and action.

Accordingly, in this study, the data from each contractors and each projects have been reduced thematically. For with in case analysis, the following themes are stereotyped from the literature review are used:

- Cost estimation practice
- Technical procedures and considerations in detailed cost estimation practice

- Estimating consistency
- Estimating team responsibility
- involvement of management in monitoring and controlling quality of estimates

After each case analysis, a cross- case analysis was conducted to compare the practices of the different contractors and identify the challenge and problem areas in the practice. Thematic analysis, themed around the above-identified topics was used to evaluate and analyze the problem and challenge areas. Figure 3:1 below presents a schematic representation of the methodology adopted and methods used.

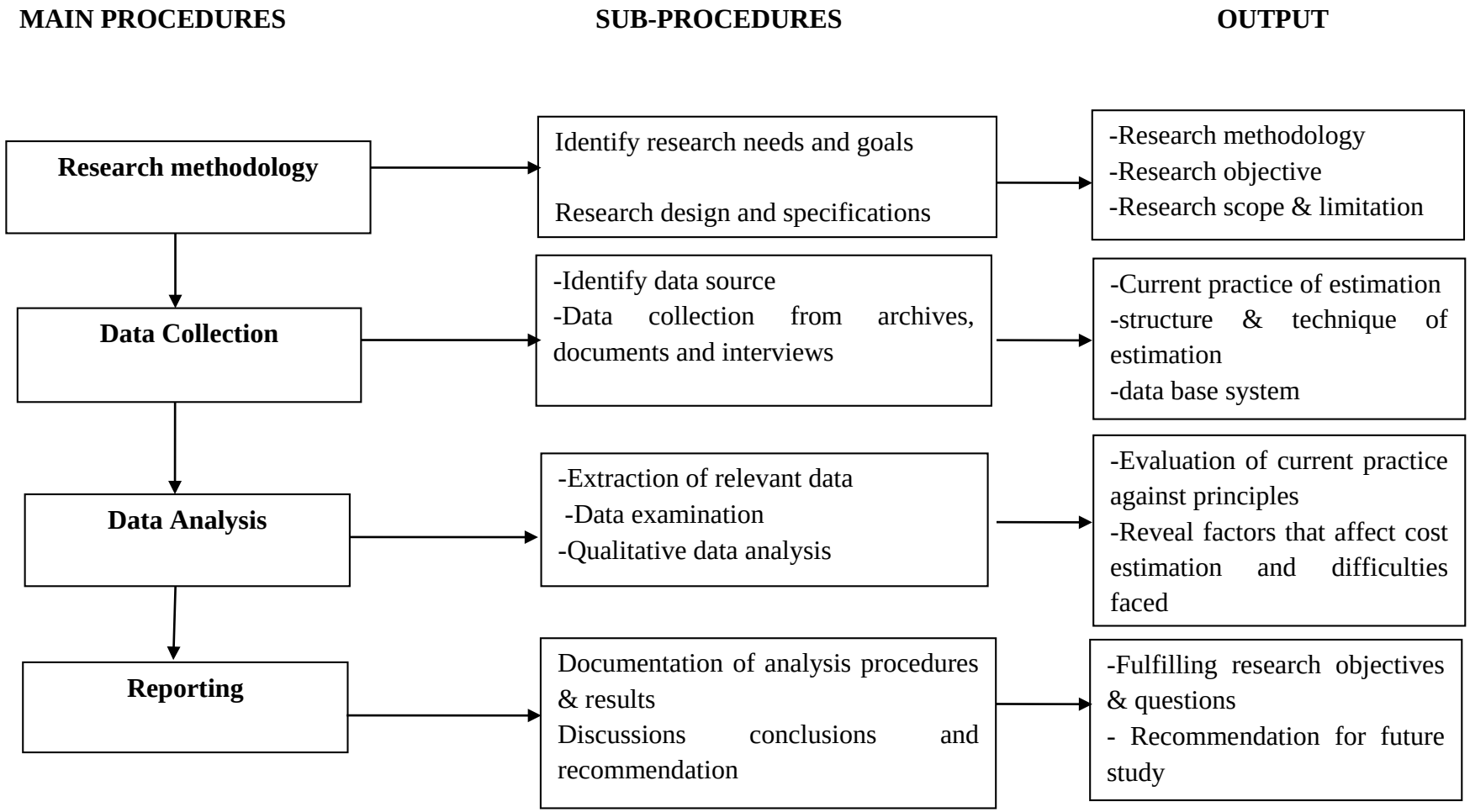

Figure 3: 1 Research methodology flowchart

CHAPTER FOUR: ANALYSIS AND DISCUSSION

4.1 Introduction

This chapter provides the analysis and discussion of the case study.

The analysis and discussions are done in three major sections summarized below

- Section 4.2 presents the case coding and gives description of the scope of the case projects
- Section 4.3 presents within case analysis of contractors cost estimating practice. Under the subsection 4.3.1, the cost estimating practice for tendering discussed raising issues on preliminary consideration for estimate preparation, inputs of cost estimate and construction cost analysis. In the same manner under the sub section 4.3.2, examined how consistent the case projects estimates are. The cost estimation practice for variation works are reviewed under section 4.3.3. Finally, in section 4.3.4, reviewed the estimating team responsibility and involvement of management.
- Section 4.4 presents the cross case analysis of contractors on the different cost estimation practice and presents the comparative outlook of the case contractors practice and challenges.

4.2 Case Description

4.2.1 Coding

For this study, the selected case company's name and project names are replaced by an alpha numeric based coding system. The numerical code represents the four case contractors and the alphabetical part represents projects under each contractor. Accordingly, the case contractors are represented as Case one (C1), Case two (C2), Case three (C3) and Case four (C4). The corresponding five projects in each case contractors are indicated by alphabetical letters as A, B, C, D and E. Thus the projects under case one contractor shall be represented as: Case one project A (C1PA), Case one Project B (C1PB), Case one Project C(C1PC), Case one Project D(C1PD) and Case one Project E(C1PE). The remaining case-contractors follow the same format of code-naming.

4.2.2 Case Presentation

As described in the literature review section, the major factors that affect construction cost estimates are method of estimating, contract duration, contract type, project complexity, project location, nature of tendering, type of client and type of consultant. Thus in order to review the cost estimation practice of the selected projects, this information is relevant and are presented in tabulated form.

Table 4.1 up to 4.4 below describes the scope of the selected projects

Table 4: 1 Description of scope projects under case one contractor

No	Description	Project A	Project B	Project C	Project D	Project E
1.1	Project description	G+4 Dormitory	G+4 office building	G+4 Dormitory	Factory buildings	Factory buildings
1.2	Method of tendering	National competitive bidding (NCB)	National competitive bidding (NCB)	National competitive bidding (NCB)	National competitive bidding (NCB)	Selective Bid
1.3	Condition of contract	PPA 2006	PPA 2006	PPA 2006	PPA 2006	PPA 2006
1.4	Contract Type	Unit Price (admeasurement)	Unit Price (admeasurement)	Unit Price (admeasurement)	Unit Price (admeasurement)	Unit Price (admeasurement)
1.5	Contract price (with VAT)	45,522,524.19 Birr	114,665,370.48 birr	21,779,201.13 Birr	190,768,959.11 Birr	94,599,512.30 Birr
1.6	Contract period	730 Cal days	960 Cal days	450 Cal days	273 Cal days	960 Cal days
1.7	Project location	Yirgalem	Bahirdar	Addis Ababa	Wonji	Tana Beles
1.8	Project start	05 June 2010	17 Dec 2008	28 July 2010	31 May 2012	24 March 2012
1.9	Project completion	04 June 2012	01 Sep 2011	21 Oct 2011	28 Feb 2013	28 March 2013
1.10	Project status	Completed	Completed	Completed	Completed	under construction
1.11	Consultant	Private.	Government	Government	Private	Private
1.12	Client	Government	Government	Government	Government	Government

Table 4: 2 Description of scope of projects under case two contractor

No	Description	Project A	Project B	Project C	Project D	Project E
1.1	Project description	G+4 Office Building	B+G+6 Office Building	G+4 Dormitory Building	B+G+8 Hotel Building	G+2 Administrative Building
1.2	Method of tendering	National competitive bidding(NCB)	National competitive bidding (NCB)	National competitive bidding (NCB)	National competitive bidding (NCB)	National competitive bidding (NCB)
1.3	Condition of contract	PPA	PPA	PPA	PPA	PPA
1.4	Contract Type	Unit Price (ad-measurement)	Unit Price (ad-measurement)	Unit Price (ad-measurement)	Unit Price (ad-measurement)	Unit Price (ad-measurement)
1.5	Contract price (inclusive of VAT)	63,063,794.21 birr	115,866,868.57 birr	151,178472.58 birr	42,635,292.3 birr	36,425,048.5 birr
1.6	Contract period	365 calendar days	600 calendar days	540 calendar days	365 calendar days	365 calendar days
1.7	Project location	Arbaminch	Debreberhan	Wolyta sodo	Bahirdar	Nekemt
1.8	Project start	11 August, 2015	05 March ,2016	19 May ,2016	30 June , 2016	02 July , 2015
1.9	Project completion	12 August , 2016	23 December,2017	11 Sept.,2017	31 July, 2017	03 July ,2016
1.10	Project status	under construction	under construction	under construction	under construction	under construction
1.11	Consultant	Private	Private	Private	Private	Government
1.12	Client	Government	Government	Government	private	Government

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Table 4: 3 Description of scope of projects under case three contractor

No	Description	Project A	Project B	Project C	Project D	Project E
1.1	Project description	B+G+3 , Hospital building	G+3,Medical college	2B+G+12, Hotel	2B+G+10, Office building	B+G+7 Office and Apartment Complex
1.2	Method of tendering	Selected	National competitive bidding (NCB)	Selected	Selected	National competitive bidding (NCB)
1.3	Condition of contract	FIDIC,1999	PPA	FIDIC,1999	PPA	PPA
1.4	Contract Type	Lump sum	Ad-measurement	Lump sum (1^{st} phase contract)	Lump sum (1^{st} phase contract)	Ad-measurement (2^{nd} phase contract)
1.5	Contract price (inclusive of VAT)	101,017,005.80 birr	116,154,889.70 birr	78,731,355 birr	54,040,061.31 birr	47, 442,331.64 birr
1.6	Contract period	Two years	796 Calendar days	730 calendar days	730 Calendar days	430 calendar days
1.7	Project location	Addis Ababa	Adama	Addis Ababa	Addis Ababa	Addis Ababa
1.8	Project start	24 May 2016	08 January 2016	15 May 2016	05 March 2015	January 2012
1.9	Project completion	24 May 2018	13 March 2017	15 May 2018	05 March 2017	April 2013
1.10	Project status	under construction	under construction	under construction	under construction	Completed
1.11	Consultant	Private	Private	Private	Private	Private
1.12	Client	Private	Private	Private	Private	Private

FIDIC-Federation Internationale Des Ignieus Conselis

Table 4: 4 Description of scope of projects under case four contractor

No	Description	Project A	Project B	Project C	Project D	Project E
1.1	Project description	G+5 Mixed-use building	B+G+7+Hotel	Aviation Depot	B+G+4 Building	Mixed use building B+G+5
1.2	Method of tendering	Shortlist	National competitive bidding	National competitive bidding	Short list ,Negotiation	National competitive bidding
1.3	Condition of contract	PPA 2006	PPA 2011	PPA 2011	PPA 2011	PPA 2011
1.4	Contract Type	Ad-measurement	Ad-measurement (Labor contract)	Ad-measurement	Ad-measurement (Labor contract)	Ad-measurement
1.5	Contract price (inclusive of VAT)	101,726,012.25 birr	12,465,143.00 birr	13,467,494.30 birr	8,465,143.00 birr	72,196,830.00 birr
1.6	Contract period	550 days	365 days	90 days	240 days	730 days
1.7	Project location	Addis Ababa	Addis Ababa	Combolcha	Addis Ababa	Addis Ababa
1.8	Project start	April 02,2013 G.C.	October 27, 2014 G.C.	Oct 21, 2015 G.C.	September 2014 G.C.	July 21, 2015 G.C.
1.9	Project completion	October 30,2014 G.C	October 27, 2015 G.C.	Jan 18, 2016 G.C.	May, 2015 G.C.	July 21, 2017 G.C.
1.10	Project status	Completed	Completed	Completed	Completed	Under construction
1.11	Consultant	Private	Private	Private	Private	Private
1.12	Client	Private	Private	Private	Private	Private

**PPA-Public Procurement Agency

4.3 Contractors Cost Estimating Practice: Within Case Analysis

The cost estimating practice of the case contractors are stereotyped based on the themes from literature review for estimates prepared at different stages of construction. Accordingly, the practice of contractors shows that cost estimates are predominantly prepared at tendering phase to fix rates for new tender projects and during construction phase to fix rates for variation works. As observed in the report, detailed cost estimating methodology is popular for estimation of tender and variation costs.

4.3.1 Cost Estimating Practice for Tendering

The decision to bid involves a study of many interrelated factors. Some of factors are related to contracting parties, project complexity, contractors' capacity and terms of contract set forth and market conditions (Clough 2011). Contractor who decides to bid shall examine different documents before preparing estimates. Some of the preliminary conditions and contractors' practices are discussed below.

4.3.1.1 Preliminary Considerations for Tender Estimate Preparation

Akintoye (2010) prescribes that the estimator, in the course of preparing a cost estimate, should carry out tasks such as a thorough examination of the tender documents, a site visit, preparation of methods statement and tender program, make enquiries and receive quotations for materials, plant and subcontractors. These tasks are required to determine an approach to pricing the project at a level at which the costs of construction resources could be recovered.

In short, the contractor prior to estimating for tender collects key information regarding the project. In line with this, the case contractors are expected to compile this information prior to estimating. The practice by contractors are investigated as discussed below.

a) Case one contractor

i.Supporting Documents

As can be seen from table 4.5, the contractor did not receive any geotechnical data for all projects. For project A, it was contractor's responsibility for conducting geological investigation before conducting permanent work. This project specifically orders the contractor to produce a soil test taking samples on the actual locations the buildings rest. However, this cost being project overhead cost, was not incorporated in cost estimation and was absorbed by the contractor.

In the same manner, as shown in table 4.5, the case contractor received drawings for project A and project C. The information from drawing was used for cross checking quantity and existence described sections of reinforcement and steel material. In addition to this, drawings were used as reference to understand the details of item description.

ii.Site Visit

For the projects evaluated under case one contractor, the contractor visited project A and project C. The contractor practice of site visit is to identify resource availability and check the local market price of labor and material. Accordingly, during cost estimation the contractor used the local market price in preparing estimates.

Other than this, the contractor did not incorporate costs due to lack of storage space at project C and the costs due to establishment of camp facilities at project A. In discussion with the contractor, they implied identified conditions were not incorporated in cost estimation due to fear of losing competition because of increased costs.

iii.Conditions of Contract

The contract clauses dealt in this section are those that have cost implication for the project and require estimators' attention. Accordingly, the contractors' practice towards contract clauses related with price adjustment, payment, variation, project duration and risks are discussed in this section.

- **Contract clauses related with price adjustment**

The conditions of contract for the reported projects under case one contractor are standard bidding document prepared by Public Procurement Agency (PPA 2006, PPA2011versions). The contract conditions in PPA provide indices method or adjustment formula. However, the provisions in contract allow price adjustment for materials comprising cement, bitumen, reinforcement bar and fuel. As the prevailing price fluctuation is not limited to the mentioned materials, the contractor is expected to include the risks of market fluctuation in their estimation. The discussion held with the contractor and evaluation of the cost analysis, showed that the contractor tried to incorporate future market inflation. Accordingly, to compensate the future price increase on certain finishing, sanitary and electrical materials, the contractor increased the profit margin of the items.

- **Contract clauses related with variations**

Additional quantity and reduction in quantity bring extra costs to the contractor. Additional quantity of work will force the contractor to rent costly equipment or will incur extra cost and difficulty to discharge his responsibility, paying for such additional expense based on the contract unit price may not be adequate compensation. In the same manner, reduction in quantity causes loss of profit and portion of the allowance for overhead in the unit price of reduced quantity. This will of course be because the reduction in quantity is large enough to affect the contractors profit and overhead allowance percent of the project cost (Kasem, 2008). Discussion held with the case contractor implied that existence of such case was not assessed during estimate preparation.

- **Contract clauses related with time for completion, delays, and extension of time**

In cases where the contract specified time is inadequate, the contractor will have to add a sum to his tender to cover possible liquidated damages or include expenses for overtime work and other costs that may arise due to rushed schedule. Discussion with the case contractor implied this condition was not assessed during estimate preparation.

- **Contract clauses related with advance and interim payments**

At the start of the project, the contractor will have to mobilize equipment, material and work force and have to construct temporary facilities and start of permanent construction works. The contractor has to check for the amount of advance payment, for the type of advance repayment guarantee and time table stated for repayment of advance payments as it has effect on the contractor's project cash flow. In addition to this, the timetable stated for interim and final payment is very crucial in that it completely affects the contractor's project cash flow.

In the projects studied, the contractor indicated that such issues in estimate preparation not considered unless the projects are lacking mobilization advance payments.

- **Contract clauses related with risk**

Proper risk allocation in construction contracts can help to reduce negative impacts that will affect the achievement of contract management efficiency. However, despite the cost implication of the contract conditions discussed; only the effect of price escalation was given consideration of its cost implications in the estimation as discussed previously.

iv.Method of Construction

The cost estimation should be prepared based on the method of construction the contractor plans to adopt; otherwise, it may not reflect the actual project cost. The method of construction is decided based on the information from drawings, specifications, estimated quantities and site conditions (Tadesse, 2006).

In the case contractor, the method of construction is prepared specifically as a requirement for technical tender document. In discussion with contractor, the contractor pointed that the methodology of construction is not referred in preparing cost estimates.

b) Case two contractor

i.Supporting Documents

This contractor did not receive geotechnical reports of projects under study whereas drawings were provided for projects A, C and E.

In discussion with the contractor, it was indicated that drawings are used to check the quantities and availability of some items provided in bill of quantity.

According to the contractor, there are cases where the provided quantity in the BOQ show significant difference while checked from the drawing and the described specifications contradict from that implied in the plans. The contractor mainly check quantity (and availability of all sections) of reinforcement bar, steel sections, the electrical boards, cables and fittings specified in the drawings are in accord with the specification. Thus contractor consider pricing their costs based on this information on the drawing, this according to the contractor decrease unnecessary price and use it as competitive advantage.

ii.Site Visit

In this contractor, the sites of four projects (A, B, C and D) were visited. In discussion with the contractor, it was implied that, the main purpose of the site visit is to get official letter from clients. Thus site visits serve for fulfilling the requirement of technical bid evaluation.

iii.Conditions of Contract

Case two and case four contractors did not consider all provisions of contract conditions raised in previous discussion with case one contractor. The contractors in their part argue that they overlooked the details due to lack of time and fear of losing competitiveness because of the possibility of cost increment.

iv.Method of Construction

As shown in table 4.5 below the contractor did not consider the specified method of construction in cost estimation.

c) Case three contractor

i. Supporting Documents

Soil investigation was not provided for all projects.

This contractor got the drawings for all studied projects. As the drawings were mandatory for lump sum projects (Project A, C and D), the contractor used drawings quantifying and as well to price the items in the bill of quantity. For the ad-measurement projects, the drawings were used to review details while estimating.

ii. Site Visit

The site visit was done for all projects. As shown in table 4.5, the contractor experiences the demolishing of existing structure for the two of the lump sum projects (Project A and D) and there was shortage of space for material storage and laydown at Project C. In addition, the contractor detected the possibility of underground water for project A and project D.

From the evaluation of the cost breakdowns and discussions held, the contractor has considered the conditions identified from site visit in preparing cost estimation. Accordingly, the cost implication due to underground water conditions considered by decreasing the performance of underground activities. The contractor did not go through analyzing the cost due to underground water.

In the same manner, the demolishing structure for project C was measured and priced as lump sum. Also for the absence of storage space, the contractor added percent of the material price to cover the expense. The storage cost was considered in the cost break down of cement and reinforcement material related work items.

iii. Conditions of Contract

Case three contractor considered the adjustment on material prices of lump sum projects.

The discussion held with the contractor and evaluation of the cost analysis, showed that the contractor tried to incorporate future market inflation. Accordingly, to compensate the future price increase on imported items of finishing, sanitary, electrical and mechanical fixtures, the contractor chose to increase the initial material prices of these items as a strategy. The contractor pointed that senior engineer at engineering head select the items and adjust the final prices based on experience. In addition, for lump sum projects the contractor adds contingency to alleviate risks due to extra work volume. In this regard, the contractor added ten percent (10%) of total project cost as contingency.

Other cost implications due to contract clauses discussed in previous discussion with case one contractor were not considered during cost estimation.

iv. Method of Construction

The method of construction for underground condition was identified. The costs considered in this case were discussed in previous (site visit) section.

d) Case four Contractor

i. Supporting Documents

As shown in table 4.5 below, this contractor also did not get geotechnical reports for all the projects under study.

The drawings were provided for project A and E. The contractor pointed that, the drawings used as reference to understand the vague descriptions in bill of quantity and specifications.

ii. Site Visit

The site visit was made for project A and E. During the site visit the contractor detected the possibility of underground water for project E. Similarly, project A did not have space for material damping and site office construction. The discussion held with the contractor and evaluation of the cost analysis, showed that the contractor tried to incorporate costs for underground water condition in to the estimate. Reducing excavation works output was used as strategy to compensate the cost implication. In the cost estimation, the costs incurred due to shortage of space was not considered.

iii. Conditions of Contract

As pointed in Table 4:5, and discussed previously under case two practice, the contractor did not consider the cost implication of the contract condition in the cost estimation.

iv. Method of Construction

The method statement of the construction was prepared for fulfilling the technical requirement of the bid. The contractor did not consider the cost implications of devised methodology during estimation.

Table 4:5 Preliminary considerations for tender estimates

Preliminary considerations	Conditions	Cost considerations taken by case contractors			
		Case one	Case two	Case three	Case four
1.Provision of supporting documents					
Geothechnical information	Provision of soil investigation report	Not provided	Not provided	Not provided	Not provided
Drawings	Provision of drawings	A & C	A, C&E	A, B, C, D&E	A & E
2.Site visit					
Condition of site	Site visit done for	A & C	A, B, C&D	A, B, C, D&E	A & E
	Difficult underground conditions	3	3	1 (for project A, D)	1 (for project E)
	Existence of existing structures to be demolished	3	3	1 (for project A, D)	3
	No space for storage and laydown	2 (for project C)	3	1 (for project C)	2 (for project A)

Notes:

1-Case present and its cost implication was considered in cost estimation

2-Case present but its cost implication was not considered in cost estimation

3-Case was not present and no extra cost implication considered

A: Project A B: Project B C: Project C D: Project D E: Project E

Table 4:5 Preliminary considerations for tender estimates: case one contractor contd.

Preliminary considerations	Conditions	Cost considerations taken by case contractors			
		Case one	Case two	Case three	Case four
2.Site visit					
Location of site	Location and quality of local const.materials	1	1	1	1
	Transportation cost of material	1	1	1	1
	Availability of labor	1	1	1	1
	Difficulty in access to site	3	2 (for project C)	3	3
Facilities	Difficulty of power, water, communication facilities	3	3	3	3
	Camp facilities	2 (for project A)	3	3	3
3.Condition of contract for clauses related with cost					
Price adjustment	Contract did not consider price adjustment clause for all items in the BOQ	1 (all projects)	2 (all projects)	1 (all projects)	2 (all projects)
	Allowances in Price adjustment was not sufficient	2 (all projects)	2 (all projects)	2 (project B, E)	2 (all projects)

Notes:

1-Case present and its cost implication was considered in cost estimation

2-Case present but its cost implication was not considered in cost estimation

3-Case was not present and no extra cost implication considered

A: Project A B: Project B C: Project C D: Project D E: Project E

Table 4:5 Preliminary considerations for tender estimates: case one contractor contd.

Preliminary considerations	Conditions	Cost considerations for projects under case contractor			
		Case one	Case two	Case three	Case four
3.Condition of contract for clauses related with cost					
Payment	Difficult time table for interim payments	3	3	3	3
	Advance payment not considered	3	3	3	3
	Material on site not considered during interim payment	3	3	3	3
Variation	Contract did not consider extra costs due to increase in volume of work	3	3	1 (project A, C& D)	3
	Contract did not consider extra costs due to reduction in volume of work	2 (all projects)	2 (all projects)	2	2
Project duration	inadequate time of completion	3	3	3	3
Risks	Contractor's risks	2 (all projects)	2 (all projects)	1 (project A, C& D)	2 (all projects)

1-Case present and its cost implication was considered in cost estimation

2-Case present but its cost implication was not considered in cost estimation

3-Case was not present and no extra cost implication considered

A: Project A B: Project B C: Project C D: Project D E: Project E

Table 4:5 Preliminary considerations for tender estimates contd.

Preliminary considerations	Conditions	Cost considerations for projects under case contractor			
		Case one	Case two	Case three	Case four
4.Method of construction					
Resource	Skill and number of working crew	2 (all projects)	2 (all projects)	2 (all projects)	2 for project A,C& D)
	type and specification of equipment	"	"	"	"
Construction	Difficulties of construction	"	"	"	"
	expected defects and remedial measures	"	"	"	"

1-Case present and its cost implication was considered in cost estimation

2-Case present but its cost implication was not considered in cost estimation

3-Case was not present and no extra cost implication considered

A: Project A B: Project B C :Project C D: Project D E: Project E

4.3.1.2 Analysis of Practices in Direct Cost Component Handling

4.3.1.2.1 Input Data for Cost Estimation

a) Case one contractor

i. Material cost data

The cost data are mostly collected based on the written quotation and telephone requests from suppliers or from other colleagues.

The contractor collected the material cost data for civil, finishing, sanitary and electrical work items. However, electronic data records are made for civil and finishing work items only. The sanitary and electrical fixture works are collected in form of written quotation and was not found in the electronic data record.

The marketing and finance department does the collection of the data on time and deliver the quotation to the contract-engineering department.

ii. Labor cost data

The costs of labor differ based on project location and skill of labor. In this contractor, labor cost is determined from local market rate around project location.

The labor cost data collected for projects are similar for all projects except project E, which included sanitary and electrical labor in addition to the civil work crew included in other projects. In addition, for subcontracted works, the subcontractor's offer is used as labor cost data however, the recorded data was not found in the electronic data record.

iii. Equipment cost data

The equipment costs are fixed by requesting rental rates at the project location and by forecasting previously collected rate based on estimator's assumptions.

Refer Appendix B, TableB-3 for Equipment cost data collected in the estimation of case projects.

b) Case two contractor

i. Material cost data

The material cost data collected for concrete, finishing, electrical and sanitary materials. The cost data are collected by sending out written quotation or telephone requests from suppliers, gathering information from other professionals and referring previous suppliers offer.

According to the contractor, the material cost data for finishing, sanitary and electrical are collected for every project. However, electronic data records were not made consistently. In addition to making surveys and sending out requests, it is the engineers' responsibility to collect the suppliers' offers.

ii. Labor cost data

The labor cost once collected for specific tender usually used as reference for pricing other tender projects around that location. The market labor cost rate used without applying labor index rate during cost estimation. In addition, the contractor uses the labor subcontract rate to price items that are subcontracted in future. In this manner electrical, sanitary, waterproofing and aluminum works estimated based on subcontractors' offer. However, records of such data are not found in electronic records. This, according to the contractor is because, the quotations are not done for every tender and there are times they price the items based on previous projects offers.

iii. Equipment cost data

The equipment costs are fixed by requesting equipment's rental rates at the project location and by forecasting previous rate based on engineering assumptions.

The equipment rental rate is not collected consistently for all projects studied. For instance, there is no record of equipment hourly rental data for project A and D.

c) Case three contractor

i. Material cost data

The material cost data is collected from local suppliers and foreign suppliers.

In this contractor, the material cost data for lump sum and admeasurement contracts have different approaches.

For instance, specialist subcontractors do the material specification and quantification for electrical, sanitary, mechanical and data infrastructure. In addition to this, the contactor request subcontractors' offer for the supply, fix and commissioning service. In this case the subcontractor offers for the total work package including material, labor, equipment and their overhead cost and profit margin. According to the contractor, mechanical and data work items of lump sum, projects (A, C and D) are priced this way.

Other than this, the contractor sends out request for quotation for electrical, sanitary and finishing items for different suppliers. The collected quotation are then compared, and the one with minimum unit price and that satisfies the specification are selected and used to compute rate.

In addition to this, for imported materials, the contractor took offers from foreign suppliers through mail and fax communication or refer to previous material prices from other projects.

Material used in civil works are not collected for every tender. According to the contractor, they refer to previous data collected and purchases done for other projects.

ii. Labor cost data

The contractor subcontracts the concrete, reinforcement, carpentry, block work, plastering and roofing works to labor subcontractors. Thus, the engineers refer to the ongoing projects labor contract rates to fix labor rates.

iii. Equipment cost data

For the equipment owned by the contractor, the equipment hourly cost is determined otherwise the contractor use market hourly rental rate to fix equipment cost.

d) Case four contractor

i. Material cost, labor and equipment cost data

According to the contractor, the material cost data was collected for all tender estimations except labor projects (Project B and D). Labor, equipment data are collected randomly, and their records are not found for the studied projects.

Material cost data are collected using telephone communications and sending out written request for quotations. However, electronic records were not done consistently.

4.3.1.2.2Cost Data Collection and Recording System

The historical data gives a fairly accurate and reliable information for the estimation of future projects. For that, properly documenting and compiling records of cost, risk and productivity from previous projects, should build the company's database. In the reported case contractors, the data kept for future reference are material, labor and equipment cost data collected during bid preparation. These cost data are kept in electronic records in an excel format and hard copy of in file records. As discussed previously, electronic records and hard copy of file records are not made consistently. Other than this, productivity and risk data from previous projects not followed and recorded. Thus, cost estimators tend to use their own assumption on those factors.

4.3.1.2.3 Determination of Material Break Down, Productivity, Crew Formation and Utilization Factor

In material cost analysis, the material breakdown give the quantity of material required to make a unit of the work item. Contractors determine the material breakdown on the bases of the construction specifications provided in the bill of quantity. Then based on the given specifications, they determine the quantities of materials from published standard manuals, from product manuals and from their experience of previous projects.

Another information required in direct cost analysis is the work out put or productivity of the assigned labor and equipment in given unit of time. Commonly, productivity is defined as the ratio of work out put to the time spent to complete that work. The most reliable source of equipment productivity is contractor's production records from past projects. Manufacturer specification also provide the theoretical productivity of the construction equipment however; the actual productivity of the equipment should be corrected using job correction factors on the ideal productivity.

The referred case contractors do not have a system of monitoring their productivity of labor and equipment. In addition to this, they do not have organized ways of collecting this data from different sites. The most common way of establishing productivity is estimators own assumptions and adopting the output of previously established breakdowns.

Similarly, in establishing crew, the case contractors adopt the formation from the previous cost break down analysis. In cases of new work items, engineers' use their judgment and assumption to form the required crew. In the same manner, in the observed cost breakdowns, utilization factor derived from the previously established breakdown. It is observed engineers use their assumptions to determine on how fully or partially engaged are the labor and equipment attributes to the job.

Theoretically, the number of crew for the job differs based on the project job schedule, the site condition, the intensity of the activity, the number and type of equipment involved and so on. Thus to determine the required crew, crew productivity and utilization factor the best approach is to refer to the historical cost information that the contractor's cost estimating, cost accounting, and cost control system has developed.

Table 4:6 below shows the contractors practice for input data base establishment & management

Table 4:6 Input data formation and management

item	Description	Case one	Case two	Case three	Case four
a	For cost information on material cost	Not consistently recorded	Not consistently recorded	Not consistently recorded	Not consistently recorded
b	For cost information on base labor cost	“	“	“	“
c	Equipment rental cost adjusted by the company	Not established	Not established	Established for owned equipment	Not established
d	Equipment rental cost from market	Not consistently recorded	Not consistently recorded	Not consistently recorded	Not consistently recorded
e	For labor productivity	Not followed, not recorded	Not followed, not recorded	Not followed, not recorded	Not followed, not recorded
f	For equipment productivity	“	“	“	“
g	For crew formation	Use Previous established breakdown and estimators assumption, not updated	Same as case one	Same as case one	Same as case one
h	historical data base for existence of the risks	Not followed, not recorded	Not followed, not recorded	Not followed, not recorded	Not followed, not recorded

4.3.1.2.4 Analysis of Material Cost

In the previous section, we have seen how contractors compile inputs of direct cost. In this section reviews the material cost analysis of the case contractors.

a) Case one contractor

To evaluate the contractor's experience for analysis of material costs, the evaluated breakdowns of the five projects did not show any technical differences.

As discussed previously, the material costs collected by this contractor focus on material for civil works. In the examined cost breakdowns, the contractor used the current material price without adjusting for future market fluctuations in computing material direct cost. It is recalled from previous discussion that the contractor considers the market inflation by increasing profit margin.

The material cost transportation cost considered only for cement, sand, aggregate and reinforcement bar. The unit cost of transportation expense derived by computing the total expense of transporting from the proposed supplier location to project site. However, in the breakdowns, the loading and unloading cost and the insurance charges for transportation to the project site not considered in cost analysis.

b) Case two contractor

As the contractor collected the costs from local suppliers, the direct cost calculation for local materials evaluated in cost analysis. Accordingly, in material cost analysis, material price before vat, transportation and handling cost are considered. The quoted material price used without forecasting for future market fluctuations even in cases where the price escalation clauses were not entertained.

According to the contractor, 2%-5% of the material price used to cover expenses of transportation and handling. However, the value of the percentage was provided based on engineers' assumption.

c) Case three contractor

As discussed previously, the subject contractor projects have undergone through lump sum and admeasurement contract types. Thus material cost analysis has different approaches for each contract type. For lump sum contracts, as the contractor is responsible for quantification and pricing, the contractor need to consider the right specification and quantities are determined

from the drawings and technical demand set by designers. It is recalled from the previous discussion that for lump sum contracts, the contractor outsourced the quantification and pricing mechanical and data infrastructure works to subcontractors. Thus, the contractor did not make direct cost analysis for these items.

Direct material cost analysis for locally available materials include material price before VAT, transportation cost to site and loading and unloading expense.

For imported materials, the material cost analysis is computed as shown below.

Relevant data collected for calculation of import expenses computed by case contractor (as shown attached in Appendix B) are:

- ✓ Currency of import and the resulting exchange rate including bank charges
- ✓ FOB Value of commercial invoice
- ✓ Quantity being imported
- ✓ HS Code for commodity
- ✓ Number of containers for consignment
- ✓ Estimated cost of sea freight and inland transport
- ✓ Estimated cost of marine transport
- ✓ "Transiting" company's charges for clearing from Modjo dry port and transporting to Addis Ababa
- ✓ Cost of unloading/ un staffing, Customs duties, sur tax, Excise tax, withholding tax and VAT for given HS Code

Cost calculations

1. Total Cost of (CIF) =Total FOB Cost+ Cost of Sea freight and inland transport Cost of Marine insurance
2. Total payable to customs=Customs Duty +Excise Tax+ VAT+ Sur Tax+ Withholding Tax
3. Estimated clearing and transport charges for the total quantity of containers
4. Estimated cost of unloading for total containers
5. Total cost of consignment sum of the above from number one to four.

Then the cost of imported item per unit computed by dividing the total cost of import by the total quantity for the item.

Refer Appendix B Table B-1 for sample import material cost analysis prepared by contractor.

d) Case four contractor

In analysis of material cost done for quotations collected from local suppliers. The contractor's cost break down indicates that material price before VAT used without adjustment and consideration of additional costs like transportation and handling.

In summary, the report shows that:

There is no difference in technique of direct cost analysis method for materials purchased from local market. However, for the materials imported from abroad, only case three-contractor made computation.

In addition, it was reported that case contractors did not consistently include the cost of transportation, loading, unloading and storage costs in material direct cost estimation.

Table 4:7 below shows the contractors practice of material cost estimation

Table 4:7 Technical procedures and considerations for material cost estimation

No	Description	Case one	Case two	Case three	Case four	Remark
1	For materials available at local market /supplier					
1.1	Material price	Material cost before VAT	Material cost before VAT	Material cost before VAT	Material cost before VAT	
1.2	Transportation cost	Not consistently determined	Not consistently determined	Not consistently determined	Not consistently determined	
1.3	Loading and unloading cost	Not consistently determined	Not consistently determined	Not consistently determined	Not consistently determined	
1.4	Storage and handling cost	Not determined	Not determined	Not determined	Not determined	
2	For materials Imported from abroad market					
2.1	Import expenses			Considered		Refer to appendix 22
2.2	Inland expenses			Considered		“
2.3	Insurances			Considered		“
2.4	Unloading expense at site			Considered		

4.3.1.2.5 Analysis of Labor Cost

- **Case one, Case two and Case four contractors**

Before analyzing the direct cost of labor for the given item, the crew productivity and the number of crew required to accomplish the work for estimated completion time are estimated.

For the projects observed, the number and set up of crew in the break down is the same, which shows that regardless of the quantity of work and the methodology followed to complete the project, there is the same crew arrangement in the breakdown. Moreover, as discussed previously the crew productivity is mostly established from the estimators own assumptions and experience. As can be seen from in table 4.8, the contractors did not index labor cost. They simply adopt the market price for determination of labor cost.

- **Case –three contractor**

As discussed in the previous section, this contractor subcontracts the concrete, reinforcement, carpentry, Block work, plastering and roofing work to labor subcontractors. Thus, the estimators refer to the ongoing projects labor contract rates as an indexed labor cost.

The case contractors determine the number of labor crew, utilization factor and crew productivity from previously established breakdown and their own assumptions.

Table 4:8 Technical procedures and considerations for labor cost estimation

No	Description	Case one	Case two	Case three	Case four	Remarks
1	Basic salary	Established from market	Established from market	-established from ongoing projects labor contract costs	Established from market	
2	Labor index	Not calculated, market cost taken	Not calculated, market cost taken	Not calculated, market cost taken	Not calculated, market cost taken	
3	No of labor /crew	Previously established cost breakdown & estimators assumption	Same as case one	Same as case one	Same as case one	
4	UF					
5	Hourly crew productivity					

4.3.1.2.6 Analysis of Equipment Cost

- **Case one, case two and case four contractors**

As previously discussed, the market rental rate for equipment is used in calculating the direct cost of equipment.

- **Case –three contractor**

The equipment hourly cost is established from market rental rate and from contractor's established price for owned equipment.

The contractor establishes the hourly cost of equipment as shown in the Appendix F, Table F-2. In determine the hourly cost of equipment, the contractor have computed the owning and operating costs as shown in appendix B-2. Compared to the guidelines supported by different literatures like Clough (2015) and Tadesse (2006), the technical computations have the under listed shortcomings:

- To calculate depreciation, the unit production method of calculating depreciation better relates with the real utilization of equipment. Whereas the contractor used straight-line method.
- Insurance charges should be considered in calculating the annual utilization hour of equipment
- Owning costs should include the property tax paid annually
- Operating costs should include the cost of lube oils, filters and grease based on the maintenance practice of the company
- For crawl mounted equipment the cost of undercarriage should be considered

In summary, the report shows that:

Contractors prefer to use the market rental rate to fix equipment hourly cost. As can be seen in Table 4.9 below, only case three contractor develop equipment hourly cost for equipment owned by the company. The considerations taken by the contractor are as per the guidelines shown in the literature.

Table 4:9 Technical procedures and considerations for equipment cost estimation

No	Description	Case one	Case two	Case three	Case four	Remark
1	Equipment cost	Established from market rental rate	Established from market rental rate	For owned equipment, contractor establishes hourly cost, otherwise use market rental rate	Established market rental rate	Refer appendix F for equipment cost calculation by case three contractor
2	Other consideration	none	none	none	none	

4.3.1.2.7 Subcontract Cost

Table 4:10 Illustrates the cost considerations done for subcontracted work items

Table 4:10 Cost considerations for subcontracted work items

Sub contracted work items	Project	Subcontract type	Cost estimation technique by contractor
Case one contractor			
Water proofing work	All projects	Provision of Material + labor	Subcontractor offer+ contractor's OH+Profit
Metal doors	Project B	Provision of Material + labor	Subcontractor offer+ contractor's OH+Profit
Window door work	All projects	Provision of Material + labor	Subcontractor offer+ contractor's OH+Profit
Sanitary ,electrical	"	Labor only	Labor price of sub-contractor +material offer by supplier+ contractor's OH+Profit
Case two contractor			
Excavation work	Project B,E	Equipment +Operator	Subcontractor offer+ contractor's OH+Profit
Water proofing work	All projects	Provision of Material + labor	Subcontractor offer+ contractor's OH+Profit
Window door work	All projects	Provision of Material + labor	Subcontractor offer+ contractor's OH+Profit
Sanitary ,electrical	"	Labor only	Labor price of sub-contractor +material offer by supplier+ contractor's OH+Profit

Table 4:10 Cost considerations for subcontracted work items

Sub contracted work items	Project	Subcontract type	Cost estimation technique by contractor
Case three contractor			
Concrete work, reinforcement work, carpentry work , Block work & plastering works	All projects	labor	Subcontractor's labor price is used to fix labor rate
Window door work	All projects	Provision of Material + labor	Subcontractor offer+ contractor's OH+Profit
Sanitary ,electrical, Mechanical	All projects	Labor only	Labor price of sub-contractor +material offer by supplier+ contractor's OH+Profit
Case four contractor			
Water proofing work	All projects	Provision of Material + labor	Subcontractor offer+ contractor's OH+Profit
Window door work	All projects	Provision of Material + labor	Subcontractor offer+ contractor's OH+Profit
Sanitary ,electrical	"	Labor only	Labor price of sub-contractor +material offer by supplier+ contractor's OH+Profit

4.3.1.3 Determination of Indirect Cost

Indirect costs include all costs, which cannot be directly booked under the specific activity but required to keep the whole project operational (Asteway, 2008). These costs are divided into two categories: project overhead and office overhead costs.

Project overhead costs refer to overhead costs incurred on the job site and office overhead costs refer to general business expenses such as the cost of owning or leasing the contractor's home office; salaries of the home office staff and so on.

The contractors practice for determination of these costs are discussed below.

- **Case one contractor**

This contractor has developed a base line overhead cost for a sample project.

According to this sample project, the calculated site OH cost items include :project staff costs, project office running expenses, transportation expenses and mobilization/demobilization costs and financial costs associated with bonds, guaranties and insurance.

However the major company OH cost items like office running expenses, head office staff wages, office rent and/or building depreciation, office furniture and equipment and transportation expenses and expenses related with tenders, insurances, bonds, guaranties, bank interests were not calculated. Instead, the head office contribution, profit and risk margin added along with the calculated indirect project cost and used as overhead and profit cost.

The assumptions used in computing overhead cost starts with determining project cost and duration.

The case contractor assumed a project direct cost of 70,000,000 birr with project duration of two years. Then project expenses considered in calculating project overhead summarized below as:

1. Supervisor staff expense for the total project duration: - the expenses assumed are salary and benefits of project manager, project engineer, office engineer, general Forman and surveyor. In estimating project staff costs, the salary and benefit scales of staffs for the total of 24 months was calculated.
2. Administration staff expenses for the assumed project duration: -the administration staff considered are administration and finance, personnel, casher, storekeeper, timekeeper,

small vehicle driver, cleaner and guard. In the same manner, the expenses for total of 24 months calculated.

3. Expenses of commonly used plant and tools in the assumed project duration: - the expenses of the monthly rental used and the total expense for project duration calculated. The commonly used plant and tools considered in this section are small vehicles, welding machine, surveying instrument, water tank, and plastic hose.
4. Office furniture equipment and material expenses: - in this section the expenses used for office furniture, stationaries, utilities and medicine are considered.
5. Provisional facilities: - these facilities include site office, store, rebar cutting shade, HCB production shed, guard house, pit latrine, staff toilet, tea room, fence, electrical and sanitary lines and fixtures and scaffolding. The costs of the facilities deducting their salvage values are taken.
6. Move in and move out cost: - the total trip assumed to be made by trucks, pick-ups are computed and taken as the move in and move out cost.
7. Financial costs: -for the project total cost of seventy million birr, the following costs were assumed:
    a. Performance bond ,1.4% of 15% of the project cost
    b. Interest up on retention amount, 3% of 5% of the project cost
    c. Interest up on the unpaid sum, for an average delay of certificate for 15 days
    d. Guarantee for mobilization advance, 2.4% of the mobilization advance
    e. Bid bond guarantee is 1% of the total project cost

Then the above costs (from 1 to 7) summed up to give project site overhead cost of 3,833,008 birr. Thus, the site overhead cost calculated as

Site overhead cost = (Project site overhead cost/assumed project direct cost) *100

Site overhead cost = 6%

In addition to this, the contractor adds the overhead contribution, which is assumed to be 8% and profit margin 15 % to the computation. Finally summing the above percentages (6%+8%+15%) gives 29%. This according to the case contractor used as base line to for overhead and profit cost calculation.

According to Wubshet (2007) as cited in Abeselom (2008), the ratio of site overhead costs to project direct cost ranges from 11.4 to 14.6%, of the direct project cost and that of company overhead is 4.5% in Ethiopia. However, as can be seen from the report the ratio of company OH cost to the assumed direct project cost for the case contractor is 8%, which is high. Similarly, site overhead cost is 6%, which is low according to the literature. The reflection of this shows that the contractor did not make the right assumptions in calculating direct cost, rather high profit margin is used to compensate the expenses.

- **Case two, case three and case four contractors**

These contractors do not have premeditated base for indirect cost estimation. They consider 15% to 25 % of the direct cost as overhead and profit on the subcontracted work items and 25%-35% of the direct cost for works performed by main contractor.

4.3.1.4 Determination of Risk and Allowance

It is very essential to incorporate risk allowance in pricing for construction project. This helps to compensate the negative impacts of different risks such as contractual, technical, political and economic risks. It was previously observed that case one contractor considered risk of material price escalation for some finishing sanitary and electrical items by increasing profit margin. In the same manner case three contractor incorporated the risks of price escalation for same items by increasing the material unit price. On the other hand, in case two and case four contractors, did not make risk allowance for price escalations.

For the studied contractors risk allowance is the most difficult item to estimate and incorporate in the cost. In addition to this, the contractors fail to identify potential risks and forecast the effects during estimating cost. The contractors also admit that they lack established historical data, time and expertise to make appropriate assessment of documents. On top of this, the contractors absorb some risks in order to stay competitive in market.

As can be seen in Table 4.11 only case one and case three contractors incorporate risks in cost estimating process. Economic risk, related to escalation of materials price, is the major risk item considered by these contractors.

Case one contractor attempts to alleviate the risk of market inflation BOQ items (tiles, sanitary fixtures and electrical fixtures) by increasing profit margin.

Whereas case three contractor anticipate the risk of market inflation and forecast material unit price. Nevertheless, both contractors do not utilize any technical method or have previous data to reach to definite figure.

Table 4:11 Techniques of incorporating risk allowance by case contractors

No	Description	Case one	Case two	Case three	Case four
1. Risk allowance					
1.1	Risks considered	Risk of market inflation For tiles, sanitary & electrical fixtures	none	Risk of market inflation For imported items	none
1.2	Technique of considering risks	By increasing profit margin	none	By forecasting material unit price, but the forecast is made based on subjective decision of estimator	none
1.3	consistency	Not consistent for all projects	none	For lump sum projects only	none
1.4	Other consideration	none	none	none	none

4.3.1.5 Determination of Profit

In the examined breakdowns, contractors combine overhead and profit in cost estimates. However, overheads are those costs associated with maintaining the contractor's organization that are not specific to any individual project. Such costs are covered by income from the various projects that the contractor undertakes during a given period (Meikle, 2015).On the other hand, profit carries its usual meaning; after all other costs are accounted for the contractor adds their margin.

4.3.2 Evaluation of Cost Estimating Frequency in Tender Projects

As illustrated in table 4:12 the aforementioned case contractors, follow three approaches to tender price.

The first approach is the contractor prepare cost breakdown for the item of works in the bill of quantity. This approach is followed for most of civil work items. This is done by generating new breakdown for new items and by updating the existing breakdowns from previous tenders. In cases where the contractor updates the previous breakdown, they update the price of labor, equipment, material and productivity based on the new project information. In the second approach, the contractor after receiving subcontractor's offer, add up their expenses along with their overhead and profit margin to fix the final cost. The third approach is that the estimator's price items based on their assumption from their previous experience, information from other colleagues or use other projects costs and predict the present tender cost without making any cost analysis for the work.

In the coming sections, the case projects are examined for the approaches followed in cost estimating. This is achieved by categorization of items that are priced based on cost break down, based on subcontractors offer and engineers' assumptions. This way how much percentage is priced based on what approach is computed against the total item present under major BoQ item. Finally, percentages were computed against the total number of items present under the major BOQ. Accordingly, the next section presents the contractors cost estimating approaches and their estimating consistency computed as discussed previously.

- **Case one contractor**

Option one- According to the above discussion and as shown in table 4:12 below, the contractor prepared cost break down for civil and finishing works.

Taking the average percentage of the five projects examined, it can be seen that the contractor prepared cost break down for masonry (100%) work consistently followed by concrete(93%), roofing(82%) ,excavation(76%) ,carpentry and joinery (74%), metal work(53%) and finishing work (67%) . In addition as evidenced in table 4:12, except masonry work, other work items did not have consistency in the detail estimating.

Option two- the contractor prepares prices based on offers from sub-contractors. This was observed in waterproofing and door - window works (each 100%), sanitary (88%) and electrical works (80%) by averaging the computation done for five projects.

As can be seen from the analysis, the contractor used the subcontractors offer to determine the prices of the water proofing and window and door work in all five projects reviewed. In the same manner an average of 80% of the sanitary and electrical work items, the contractor collected material prices from suppliers and took the labor contractors offer and the contractor added the cost of overhead and profit margins to determine the final cost.

Option three-the contractor predicts prices based from previous experience and by requesting information from colleagues. In this manner, averaging the computation done for five projects, carpentry and joinery (65%), excavation and earthwork (44%) were the top frequent items determined this way.

Table 4 :12 Tender cost estimating practice by case one contractor

Table 4:12 Cost estimate practice for tender, case one-contractor projects

No	Description of major work items in Bill of quantity	Projects	Pricing method					
			Option1*	%	Option 2*	%	Option 3*	%
01	Excavation and Earth work	Project A					✓	100%
		Project B	✓	80%			✓	20%
		Project C	✓	79%			✓	21%
		Project D	✓	74%			✓	26%
		Project E	✓	73%			✓	27%
02	Concrete work	Project A	✓	100%				
		Project B	✓	80%			✓	20%
		Project C	✓	83%			✓	17%
		Project D	✓	100%				
		Project E	✓	100%				
03	Masonry & block work	Project A	✓	100%				
		Project B	✓	100%				
		Project C	✓	100%				
		Project D	✓	100%				
		Project E	✓	100%				

Option 1-Detailed cost breakdown performed by the contractor

Option 2- Prices are prepared based on offer from specialist subcontractor

Option 3 -Prices are predicted based on the estimators' experience, previous projects and information from colleagues

Table 4:12 Cost estimate practice for tender, case- one contractor projects contd.

No	Description of major work items in Bill of quantity	Projects	Pricing method					
			Option1*	%	Option 2*	%	Option 3*	%
04	Roofing work	Project A	✓	100%				
		Project B	✓	80%			✓	20%
		Project C	✓	73%			✓	27%
		Project D	✓	84%			✓	16%
		Project E	✓	74%			✓	26%
05	Thermal moisture protection	Project A			✓	100%		
		Project B			✓	100%		
		Project C			✓	100%		
		Project D			✓	100%		
		Project E			✓	100%		
06	Metal work	Project A	✓	60%			✓	40%
		Project B	✓	27%	✓	38%	✓	35%
		Project C	✓	60%			✓	40%
		Project D	✓	60%			✓	40%
		Project E	✓	60%			✓	40%

Option 1-Detailed cost breakdown performed by the contractor

Option 2- Prices are prepared based on offer from specialist subcontractor

Option 3 -Prices are predicted based on the estimators' experience, previous projects and information from colleagues

Table 4:12 Cost estimate practice for tender, case- one contractor projects contd.

No	Description of major work items in Bill of quantity	Projects	Pricing method					
			Option1*	%	Option 2*	%	Option 3*	%
07	Carpentry and joinery work	Project A	✓	20%			✓	80%
		Project B	✓	50%			✓	50%
		Project C	✓	100%				
		Project D	✓	100%				
		Project E	✓	100%				
08	Wood and plastic work	Project A			✓	60%	✓	40%
		Project B			✓	45%	✓	55%
		Project C			✓	65%	✓	35%
		Project D			✓	70%	✓	30%
		Project E			✓	63%	✓	37%
09	Window and door work	Project A			✓	100%		
		Project B			✓	100%		
		Project C			✓	100%		
		Project D			✓	100%		
		Project E			✓	100%		

Option 1-Detailed cost breakdown performed by the contractor

Option 2- Prices are prepared based on offer from specialist subcontractor

Option 3 -Prices are predicted based on the estimators' experience, previous projects and information from colleagues

Table 4:12 Cost estimate practice for tender, case -one contractor projects contd.

No	Description of major work items in Bill of quantity	Projects	Pricing method					
			Option1*	%	Option 2*	%	Option 3*	%
10	Finishing work	Project A	✓	52%			✓	48%
		Project B	✓	69%			✓	31%
		Project C	✓	77%			✓	23%
		Project D	✓	83%			✓	17%
		Project E	✓	54%			✓	46%
11	Sanitary work	Project A			✓	73%	✓	27%
12	Electrical work	Project B			✓	68%	✓	32%
		Project C			✓	100%		
		Project D			✓	100%		
		Project E			✓	100%		

Option 1-Detailed cost breakdown performed by the contractor

Option 2- Prices are prepared based on offer from subcontractor and supplier

Option 3 -Prices are predicted based on the estimators' experience, previous projects and information from colleagues

- **Case two contractor**

Similarly, in this contractor by averaging computation done for the five projects detailed estimates were fully done for masonry works followed by concrete (92%), roofing (91%), metalwork (83%), carpentry and joinery (77%) and finishing work (75%).

In the same manner it was observed that door and window works, sanitary and electrical works (each 100%), water proofing works (87%), mechanical works (77%) and excavation & earth work (74%) were the most frequent items priced by using option two (price based on subcontractors offer).

On the other hand, wood and plastic (with average of 41% from two projects) was the most frequent item priced based on option three (price based on engineers' assumptions)

Table 4:13 Tender cost estimating practice by case two contractor

Table 4:13 Cost estimate practice for tender, case- two contractor projects

No	Description of major work items in Bill of quantity	Projects	Pricing method					
			Option1*	%	Option 2*	%	Option 3*	%
01	Excavation and Earth work	Project A	✓	90%			✓	10%
		Project B	✓	20%	✓	80%		
		Project C	✓	87%			✓	13%
		Project D	✓	82%			✓	18%
		Project E	✓	27%	✓	67%		
02	Concrete work	Project A	✓	100%				
		Project B	✓	88%			✓	12%
		Project C	✓	92%			✓	8%
		Project D	✓	100%				
		Project E	✓	80%	✓	20%		
03	Masonry & block work	Project A	✓	100%				
		Project B	✓	100%				
		Project C	✓	100%				
		Project D	✓	100%				
		Project E	✓	100%				

Option 1-Detailed cost breakdown performed by the contractor

Option 2- Prices are prepared based on offer from specialist subcontractor

Option 3 -Prices are predicted based on the estimators' experience, previous projects and information from colleagues

Table 4:13 Cost estimate practice for tender, case two-contractor projects contd.

No	Description of major work items in Bill of quantity	Projects	Pricing method					
			Option1*	%	Option 2*	%	Option 3*	%
04	Roofing work	Project A	✓	90%			✓	10%
		Project B	✓	87%			✓	13%
		Project C	✓	95%			✓	5%
		Project D	✓	82%			✓	18%
		Project E	✓	100%				
05	Thermal moisture protection	Project A	✓	20%	✓	80%		
		Project B	✓	17%	✓	76%	✓	7%
		Project C			✓	95%	✓	5%
		Project D			✓	82%	✓	18%
		Project E			✓	100%		
06	Metal work	Project A	✓	82%			✓	18%
		Project B	✓	77%			✓	23%
		Project C	✓	85%			✓	15%
		Project D	✓	69%			✓	31%
		Project E	✓	100%				

Option 1-Detailed cost breakdown performed by the contractor

Option 2- Prices are prepared based on offer from specialist subcontractor

Option 3 -Prices are predicted based on the estimators' experience, previous projects and information from colleagues

Table 4:13 Cost estimate practice for tender, case two-contractor projects contd.

No	Description of major work items in Bill of quantity	Projects	Pricing method					
			Option1*	%	Option 2*	%	Option 3*	%
07	Carpentry and joinery work	Project A	✓	68%			✓	32%
		Project B	✓	72%			✓	28%
		Project C	✓	85%			✓	15%
		Project D	✓	62%			✓	38%
		Project E	✓	100%				
08	Wood and plastic work	Project A			✓	50%	✓	50%
		Project D	✓	69%			✓	31%
09	Window and door work	Project A			✓	100%		
		Project B	✓	80%			✓	20%
		Project C			✓	100%		
		Project D			✓	100%		
		Project E			✓	100%		
10	Finishing work	Project A	✓	73%			✓	27%
		Project B	✓	84%			✓	16%
		Project C	✓	62%			✓	38%
		Project D	✓	70%			✓	30%
		Project E	✓	87%			✓	13%

Option 1-Detailed cost breakdown performed by the contractor

Option 2- Prices are prepared based on offer from subcontractor

Option 3 -Prices are predicted based on the estimators' experience, previous projects and information from colleagues

Table 4:13 Cost estimate practice for tender, case two-contractor projects contd.

No	Description of major work items in Bill of quantity	Projects	Pricing method					
			Option1*	%	Option 2*	%	Option 3*	%
11	Sanitary work	Project A			✓	100%		
		Project B			✓	100%		
		Project C			✓	100%		
		Project D			✓	100%		
		Project E			✓	100%		
12	Electrical work	Project A			✓	100%		
		Project B			✓	100%		
		Project C			✓	100%		
		Project D			✓	100%		
		Project E			✓	100%		
13	Mechanical work	Project A			✓	73%	✓	27%
		Project E			✓	80%	✓	20%

Option 1-Detailed cost breakdown performed by the contractor

Option 2- Prices are prepared based on offer from subcontractor

Option 3 -Prices are predicted based on the estimators' experience, previous projects and information from colleagues

- **Case three contractor**

In case of the aforementioned case contractor, the tender prices provided for lump sum and admeasurement contract types are discussed separately.

Out of the five projects, three projects are engaged in the lump sum fixed price contract type. This contract type requires the contractor to execute the project based on a fixed lump sum price, which shall not be subjected to any variations unless the drawings and specifications are altered beyond the maximum limit stated in the contract conditions by the owner.

In case of lump sum contracts (Project A, C and D) the contractor followed the listed three approaches of pricing.

Approach one –In this case, the contractor prepare bill of quantities based on the drawings, site conditions and client's preferences and finally produce new cost breakdowns.

In this approach by averaging computation done for the three lump sum projects detailed estimates were done in the following frequencies; Excavation and earth work (88%), concrete and glazing (88% each), roofing and water proofing work (85 %each), painting (83%), finishing work (82%), Walling work (79%), metal work (77%) and carpentry and joinery (64%).

Approach two- The contractor outsourced mechanical, plumbing, electrical, data infrastructure works to specialist subcontractors. In this case, the subcontractors in addition to quantification and preparing bill of quantity of the work items, they also priced the items. The contractor after receiving the specifications and offers of the subcontractors, prepared their cost by adding allowances for provision of storage, construction of temporary facilities and supervision of the work along with their overhead and profit cost. Thus, all the sanitary and electrical works of the projects (A, C & D) were determined this way. For the mechanical and data works, similar to electrical works subcontractors offer was used but here subcontractor makes the offer for total supply, fix and commission.

Approach three- the pricing based on engineers' experience from previous projects

In this approach, where the prices are predicted based on the estimator's assumptions, previous projects experiences and information from colleagues. By averaging computation done for the three lump sum projects; carpentry and roofing (36%) and metal work (23%) were the most frequent items determined this way.

In case of admeasurement contracts, the contractor followed the same approach of pricing as of case one and case two contractors.

Accordingly, by averaging computation done for the two admeasurement contract projects detailed estimates were done in the following frequencies; masonry and block work (100%), Concrete work (94%), Carpentry and joinery (93%), roofing work (89%), finishing work (87%) and window and door (77%).

Table 4:14 Tender cost estimating practice by case three contractor

Table 4: 14 Cost estimate practice for tender, case- three contractor projects

No	Description of major work items in Bill of quantity	Projects (lump sum)	Pricing method					
			Option1*	%	Option 2*	%	Option 3*	%
01	Excavation and Earth work	Project A	✓	82%			✓	18%
		Project C	✓	88%			✓	12%
		Project D	✓	94%			✓	6%
02	Concrete work	Project A	✓	100%				
		Project C	✓	80%			✓	20%
		Project D	✓	85%			✓	15%
03	Walling work	Project A	✓	70%			✓	30%
		Project C	✓	86%			✓	14%
		Project D	✓	82%			✓	18%
04	Roofing work	Project A	✓	100%				
		Project C	✓	73%			✓	23%
		Project D	✓	82%			✓	18%

Option 1-Preparation of quantity, specification and detailed cost breakdown performed by the contractor (Approach one)

Option 2- Preparation of quantity, specification and pricing by specialist subcontractor and contractor add allowances (Approach Two)

Option 3 - Preparation of quantity, specification prepared by contractor and prices are predicted based on the engineers' experience from previous projects

Table 4:14 Cost estimate practice for tender, case-three contractor projects contd.

No	Description of major work items in Bill of quantity	Projects (lump sum)	Pricing method					
			Option1*	%	Option 2*	%	Option 3*	%
05	Steel structure	Project A	✓	100%				
		Project C	✓	73%			✓	27%
		Project D	✓	82%			✓	18%
06	Carpentry and joinery	Project A	✓	63%			✓	37%
		Project C	✓	73%			✓	27%
		Project D	✓	55%			✓	45%
07	Metal works	Project A	✓	83%			✓	17%
		Project C	✓	79%			✓	21%
		Project D	✓	69%			✓	31%
08	Finishing works	Project A	✓	76%			✓	24%
		Project C	✓	84%			✓	16%
		Project D	✓	87%			✓	13%

Option 1-Preparation of quantity, specification and detailed cost breakdown performed by the contractor (Approach one)

Option 2- Preparation of quantity, specification and pricing by specialist subcontractor and contractor add allowances (Approach Two)

Option 3 - Preparation of quantity, specification prepared by contractor and prices are predicted based on the engineers' experience from previous projects

Table 4:14 Cost estimate practice for tender, case –three-contractor projects contd.

No	Description of major work items in Bill of quantity	Projects (lump sum)	Pricing method					
			Option1*	%	Option 2*	%	Option 3*	%
09	Glazing	Project A	✓	65%			✓	35%
		Project C	✓	100%				
		Project D	✓	100%				
10	Painting	Project A	✓	87%			✓	13%
		Project C	✓	92%			✓	8%
		Project D	✓	71%			✓	29%
11	Plumbing works Mechanical works Electrical works	Project A			✓	100%		
		Project C			✓	100%		
		Project D			✓	100%		

Option 1-Preparation of quantity, specification and detailed cost breakdown performed by the contractor (Approach one)

Option 2- Preparation of quantity, specification and pricing by specialist subcontractor and contractor add allowances (Approach Two)

Option 3 - Preparation of quantity, specification prepared by contractor and prices are predicted based on the engineers' experience from previous projects

Table 4:14 Cost estimate practice for tender- case three contractor projects contd.

No	Description of major work items in Bill of quantity	Projects (admeasurement)	Pricing method					
			Option1*	%	Option 2*	%	Option 3*	%
01	Excavation and earthwork work	Project B	✓	20%	✓	80%		
		Project E	✓	87%			✓	13%
02	Concrete work	Project B	✓	100%				
		Project E	✓	88%			✓	12%
03	Masonry & block work	Project B	✓	100%				
		Project E	✓	100%				
04	Roofing work	Project B	✓	90%			✓	10%
		Project E	✓	87%			✓	13%
05	Thermal moisture protection	Project B	✓	20%	✓	80%		
		Project E	✓	17%	✓	76%	✓	7%
06	Metal work	Project B	✓	82%			✓	18%
		Project E	✓	69%			✓	31%
07	Carpentry work	Project B	✓	85%			✓	15%
		Project E	✓	100%				

Option 1-Detailed cost breakdown performed by the contractor

Option 2- Prices are prepared based on offer from specialist subcontractor

Option 3 -Prices are predicted based on the estimators' experience, previous projects and information from colleagues

Table 4:14 Cost estimate practice for tender- case three contractor projects contd.

No	Description of major work items in Bill of quantity	Projects (admeasurement)	Pricing method					
			Option1*	%	Option 2*	%	Option 3*	%
08	Wood and plastic work	Project B			✓	50%	✓	50%
		Project E	✓	69%			✓	31%
09	Window and door work	Project B	✓	73%			✓	27%
		Project E	✓	80%			✓	20%
10	Finishing work	Project B	✓	83%			✓	17%
		Project E	✓	90%			✓	10%
11	Sanitary work	Project B	✓	65%			✓	35%
		Project E	✓	57%			✓	43%
12	Electrical work	Project B	✓	13%	✓	50%	✓	37%
		Project E	✓	22%	✓	63%	✓	15%
13	Mechanical work	Project B			✓	100%		
		Project E			✓	1000%		

Option 1-Detailed cost breakdown performed by the contractor

Option 2- Prices are prepared based on offer from subcontractor

Option 3 -Prices are predicted based on the estimators' experience, previous projects and information from colleagues

- **Case four contractor**

In this contractor, all projects are admeasurement contracts where project B and project D are labor contracts and the other three projects are priced for total package of the work.

In case of labor contracts, there are three approaches in pricing.

In the first case, the contractor prepares detailed breakdown for provision of labor, equipment, and ancillary materials and include their overhead expenses and profit margin. The second approach is taking the labor cost offers by subcontractors especially for electrical and sanitary items and the contractor add their overhead expenses and profit margin. In the third case, for similar project items the contractor adopts the unit price from the previously estimated projects where the project areas are located at the same area. In the cases where the contractor is responsible for the provision of personnel and technical resources for the construction; they execute new break down for material, labor and equipment provision or adopt previously executed cost breakdowns or use subcontractors offer as reference. In both cases, the approaches are the same.

In this contractor, by averaging computation done for the five projects detailed estimates were done in the following frequencies; concrete (96%), excavation and earth work (95%), masonry (94%), metal work (85%), carpentry and joinery (67%), and finishing work (70%).

In the same manner price based on the subcontractor's offer was done in the following frequencies: sanitary and electrical work (100%), waterproofing works (92%) and door-window work (85%).

For prices predicted based on the estimator's assumptions, previous projects experiences and information from colleagues; Carpentry and roofing (33% taking average of the five projects), wood and plastic (62% from two projects) were the most frequent items determined this way.

Table 4:15 Tender cost estimating practice by case four contractor

Table 4:15 Cost estimate practice for tender, case -four contractor projects

No	Description of major work items in Bill of quantity	Pricing method	Cost estimating method followed in tender pricing of					
			Option1*	%	Option 2*	%	Option 3*	%
01	Excavation and Earth work	Project A	✓	82%			✓	18%
		Project B	✓	100%				
		Project C	✓	92%			✓	8%
		Project D	✓	100%				
		Project E	✓	87%			✓	13%
02	Concrete work	Project A	✓	100%				
		Project B	✓	100%				
		Project C	✓	93%			✓	7%
		Project D	✓	100%				
		Project E	✓	87%			✓	13%
03	Masonry & block work	Project A	✓	100%				
		Project B	✓	100%				
		Project C	✓	83%			✓	17%
		Project D	✓	100%				
		Project E	✓	87%			✓	13%

Option 1-Detailed cost breakdown performed by the contractor

Option 2- Prices are prepared based on offer from specialist subcontractor

Option 3 -Prices are predicted based on the estimators' experience, previous projects and information from colleagues

Table 4:15 Cost estimate practice for tender, case- four contractor projects contd.

No	Description of major work items in Bill of quantity	Projects	Pricing method					
			Option1*	%	Option 2*	%	Option 3*	%
04	Roofing work	Project A	✓	90%			✓	10%
		Project B	✓	100%				
		Project C	✓	93%			✓	7%
		Project D	✓	100%				
		Project E	✓	87%			✓	13%
05	Thermal moisture protection	Project A			✓	80%	✓	20%
		Project B			✓	100%		
		Project C			✓	93%	✓	7%
		Project D			✓	100%		
		Project E			✓	87%	✓	13%
06	Metal work	Project A	✓	68%			✓	32%
		Project B	✓	100%				
		Project C	✓	72%			✓	28%
		Project D	✓	100%				
		Project E	✓	87%			✓	13%

Option 1-Detailed cost breakdown performed by the contractor

Option 2- Prices are prepared based on offer from specialist subcontractor

Option 3 -Prices are predicted based on the estimators' experience, previous projects and information from colleagues

Table 4:15 Cost estimate practice for tender, case -four contractor projects contd.

No	Description of major work items in Bill of quantity	Projects	Pricing method					
			Option1*	%	Option 2*	%	Option 3*	%
07	Carpentry and joinery work	Project A	✓	65%			✓	35%
		Project B	✓	70%			✓	30%
		Project C	✓	78%			✓	22%
		Project D	✓	63%			✓	37%
		Project E	✓	58%			✓	42%
08	Wood and plastic work	Project A	✓	44%			✓	56%
		Project B						
		Project C	✓	33%			✓	67%
		Project D					✓	100%
		Project E	✓	27%			✓	73%
09	Window and door work	Project A			✓	100%	✓	100%
		Project B			✓	67%	✓	33%
		Project C			✓	100%		
		Project D	✓	20%	✓	80%		
		Project E			✓	78%	✓	22%

Option 1-Detailed cost breakdown performed by the contractor

Option 2- Prices are prepared based on offer from specialist subcontractor

Option 3 -Prices are predicted based on the estimators' experience, previous projects and information from colleagues

Table 4:15 Cost estimate practice for tender, case -four contractor projects contd..

No	Description of major work items in Bill of quantity	Projects	Pricing method					
			Option1*	%	Option 2*	%	Option 3*	%
10	Finishing work	Project A	✓	55%			✓	45%
		Project B	✓	78%			✓	22%
		Project C	✓	63%			✓	37%
		Project D	✓	89%			✓	11%
		Project E	✓	65%			✓	35%
11	Sanitary work	Project A			✓	100%		
		Project B			✓	100%		
		Project C			✓	100%		
		Project D			✓	100%		
		Project E			✓	100%		
13	Electrical work	Project A			✓	100%		
		Project B			✓	100%		
		Project C			✓	100%		
		Project D			✓	100%		
		Project E			✓	100%		

Option 1-Detailed cost breakdown performed by the contractor

Option 2- Prices are prepared based on offer from specialist subcontractor

Option 3 -Prices are predicted based on the estimators' experience, previous projects and information from colleagues

4.3.3 Cost Estimation Practice for Variation Work

In addition, preparing cost estimation for tendering purpose, contractors prepare detailed cost estimation to quote price of variation works. The experience of case contractors show that they prepare breakdown for every variation item of work. Here the contractors are expected to come up with the present market costs of the material, labor and equipment.

From discussions with contractors, it was implied that cost estimates prepared for variation works are relatively clear and accurate. The reason given by contractors was that as the specifications and requirements of the work is clear and the risks are known. In addition, the estimates are subjected to evaluation by approving party and should be clear. However, the contractors agree that due to difference in assumptions on the productivity and crew formation, they face disagreement with the variation approving party.

In this research, all the cases report to face these kinds of issues on the variation work cost estimates.

4.3.4 Estimating Team Responsibility and Involvement of Management

- Case one contractor

The case contractor has different divisions of departments the estimating team for this contractor is the contract department. In this section, the major responsibility of this team is preparing tender technical and financial documents. Along with the tendering procedures the estimating engineers are expected to understand the tender document, identify the material cost, labor cost gather this cost data either by liaising the material cost data for purchasers or by directly requesting suppliers and furnish the cost estimates for the projects under bid and record the cost data for future references.

The involvement of management is limited to evaluating the final tender prices.

The head of contract department and deputy manager review the cost estimates and amend final tender prices.

- Case two contractor

Operation and contract department do the cost estimation.

The preparation of tendering estimating starts by studying the drawings (if available) and quantity checking for some items. The engineers are responsible for sending out requests to suppliers and collecting the quotations.

The collected cost data are recorded in excel format. The deputy general manager reviews the tender offers and decides on costs to be amended before submitting to tender.

- Case three contractor

The cost estimation is done by internal office engineering department and special sub-contractors (for lump sum contracts).The office engineering department is responsible for studying the documents, preparing quantity (in case of lump sum contracts) and identifying the required quotations. The purchasing department is liaised to distribute the quotations to different suppliers and fetch the proforma from the suppliers. The cost estimators select the with least cost and well suited to the specification.

The engineering head collects and price the imported material costs and forecasts prices of some finishing, sanitary fixtures and electrical fixtures. The engineering head also gives the final review of the cost breakdown and adjust tender price accordingly.

- Case four contractor

The estimating team in this contractor is the tender and procurement department. The team is responsible for tender document preparation, estimating and follow up of ongoing projects. The cost estimators collects cost information mostly through telephone requests from usual suppliers and by sending out quotations. The collected cost data are recorded for material only.

The technical director review the tender prices and decides on the final tender price to be submitted.

4.4 Cross Case Analysis of Contractors Cost Estimating Practice

4.4.1 The Practice of Different Cost Estimation Techniques

Contractors mainly prepare cost estimate to price tenders for clients, quote for variation works, to evaluate tender to bid and lesser amount to monitor project.

The main technique used by the case contractors is detailed estimating technique where the costs of construction (labor, material, plant, subcontractors) are established and to which an allowance for overheads and profit is added. However as critiqued by Akintoye and Fitzgerald (2000), this method of cost estimating is deterministic (single point number) in its nature and fails to cope with the realities of today's world, which involves uncertainty due to the risk of overestimating or underestimating.

To counter this problem Curran (1990) suggests the use of range estimating techniques by contractors as part of their estimating process. Range estimating can be used as a decision support system in addition to the traditional estimating. Range estimating could provide information on the probability of cost over run, on how large the overrun can be, and on what to do to eliminate or reduce cost overrun risk, including how much contingency to add to the estimate in order to reduce any residual risk to an acceptable level.

The contractors were interviewed why they were not using other groups of estimating methods other than detailed estimating.

They responded that

- ✓ They believe the competitive tender are better suited to detailed estimating
- ✓ lack of familiarity with the techniques
- ✓ fear of degree of sophistication involved in the techniques
- ✓ they believe the techniques require sound data of previous projects and system to monitor which they do not have

It is reported that parametric and comparative cost estimating techniques used to filter better tender projects in cases where multiple tender opportunities exist. As can be seen in table 4:16 below, case one and case four contractors select tender to bid by comparison with previous projects cost and based on the management decision on the current load of projects and other factors.

In case three contractor, there is experience of using parametric estimating for selecting tender to bid. In this contractor, the senior engineer determines the range of the project cost by calculating area of the building with estimated birr/m2 amount. The birr/m2 amount is determined from previous projects experience taking in to consideration of different cost driving factors.

On the other hand, case two-contractor selection of tender to bid is rather dependent on the management decision than filtering tender based on cost.

The study revealed that the main use of cost estimating for the studied cases is for tender sum preparation in response to an invitation to bid by construction clients.

The study tried to examine the use of cost estimation in monitoring project costs and using it as feedback for other projects. However, the contractors do not have the experience.

Table 4.16 shows construction contractors' practice of cost estimation techniques.

Table 4:16 Purpose and techniques of cost estimation

		Case one	Case two	Case three	Case four
1.Purpose of preparing cost estimate					
1.1	To prepare tender for client	✓	✓	✓	✓
1.2	For variation :compile quotes for changes in the work	✓	✓	✓	✓
1.3	To monitor project execution				
1.4	To select projects to tender for	✓		✓	✓
2.Techniques of cost estimating					
2.1	Estimating standard procedure	✓	✓	✓	✓
2.2	Comparison with similar past experience based on personal experience	✓	✓	✓	✓
2.3	Comparison with similar past projects based on documented facts	✓	✓	✓	✓
2.4	Intuition	✓	✓	✓	✓
2.5	Published price information				
2.6	Cost estimating software				

4.4.2 Comparative Outlook

The comparative outlook of the four case contractors is themed around input data, cost analysis techniques and cost estimate output.

4.4.2.1 Input Data

4.4.2.1.1 Project Information

The fundamental project information that cost estimators should assess before preparing estimate include project information and construction methodology of the project.

i. Geotechnical Reports

Geotechnical reports are basic information reviewed while estimating the foundation work. However, the study reported that all contractors were not provided with Geotechnical documents. From the discussion and observation of the researcher cost analysis methodology, that is concluded contractors depend on the information that is provided on the specification to determine the cost of the foundation works.

ii. Drawings

Drawings contribute vivid information on the unique nature of the project and indicate the complex nature that needed to be incorporated in cost consideration. Thus, contractors are expected to study drawings prior to preparing the estimate. However, drawings were not provided for all projects under study for case one, two and four contractors. In this regard, out of five projects studied drawings provided for two projects, (each under case one and case four contractors) besides that for three projects under case two contractor. On the other hand, case three contractor reported to receive drawings for all the projects under study.

From the above discussion, the case contractors indicated that there is no enough time to study drawings, however, they refer drawings to understand the details specified in the bill of quantity. In addition to that, contractor crosschecked the quantities specified in the BOQ in according to the drawings. In this regard, case one and case two contractors have an experience of checking reinforcement/steel quantity also an existence of specified items from drawings. However, case contractors reported there are times they find ambiguity between drawings and BOQ specification, which leave contractors to take their own assumption in price quoting. On the other hand, with respect to the case three contractor, drawings required for project cost

estimation, as the contract is a lump sum for project A, C and D. Thus, the contractor uses the drawings for detail quantification and as well cost estimation.

iii. Site Visit

The study indicated that contractors made site visit for twelve projects out of the total twenty projects studied. Case one contractor visited two projects, case two visited three projects, case three visited all the projects (understudy) and case four visited two projects. It evidenced that case three contractor has better practice visiting all sites before preparing cost estimates.

The discoveries of the site visit established difficult underground conditions as identified by case three and case four contractors, existence of structures to be demolished as identified by case three contractor and inadequate space for material damping and storage as identified by case one, case three and case four contractors.

In this regard, case three and case four contractors have better practice of incorporating the cost associations in cost estimation. The contractors took the strategy of decreasing the underground works performance to compensate the costs incurred due to difficult underground conditions. In reflection this shows that, the contractors did not do actual analysis of cost for pumping out and its propagated effects on subsequent activities. In the same manner, case three contractor uses the strategy of adding percentage of the material cost to cover the expense due to storage rental. However, these costs are only considered in cost analysis of cement and reinforcement related work items. As established from the report, the contractor did not go through actual estimation of the storage cost. Moreover, as these costs are project overhead costs, should be considered in indirect cost estimation.

In regarding to the existence structures, to be demolished, the contractor reported performing the analysis of the cost and provided as lump sum. However, the cost analysis done for this item was not found in the record. In light of this, it can be seen that the findings of the site visit are not properly analyzed in cost estimation, though to some extent attempts were made by case three and case four contractors. In the contrast, case one and case two contractors did not attempt to incorporate these costs at all.

iv. Condition of Contract

Construction contracts have impact on the cost of the project. In reference to this, the clauses related to price adjustment, payment, variation, project duration and risks were studied. The report indicated that case one and case three contractors have better experience of analyzing the effect of price adjustment and risk clauses in their estimation. In contrast, case two and case four contractors did not attempt to incorporate these costs. The contractors (case one and case three) considered the effect of market inflation for certain finishing, sanitary and electrical materials. Thus to alleviate the risks of future market inflation, case one contractor chooses increasing profit margin as a strategy while case three contractor forecasted the increase in material cost by certain percentage.

In the same manner, case three contractor incorporated the costs incurred due to different risks for lump sum projects (project A, C and D). In these projects, the contractor used contingency percentage to alleviate risks due to increased work volume.

In light of this, it can be seen that the economic risks that the contract clauses transfer to contractors needs to be properly analyzed in cost estimation. The efforts made by case one and case three contractors are made based on intuition. Thus, the practice calls for proper document assessment and analysis of economic risks. There are different ways of estimating these costs, for instance contractors could trace the local and international market trends and use the changes in price index in calculation of economic risks (literature review section 2.7.3).

v. Construction Methodology

After having the clear concept on the project information, the methodology of construction is devised for the project. The construction method statement indicates the requirement in quality and quantity of labor, material and equipment resources, proposed working crews, estimated crew productivity, estimated duration for completion and expected defects and remedial measures (Tadesse, 2006).

Thus in preparation of cost estimation the effect of the construction methodology from resource allocation and difficulty of construction are reviewed. It is observed that resource allocation identified in the method statement are used in preparing cost estimation. Specifically, case one and case three contractors use the transport costs of the materials from supplier and/or nearby factory location identified in the methodology. On the other hand, case two and case four

contractors use the method statement in their estimation rather it was used for fulfilling the technical requirement of the bid.

However, from the above discussion it can be seen that case contractors do not make use of the devised project methodology to guide their cost estimation. Indeed, tough competition and shortage of time to prepare breakdowns in such detail made them to overlook on these issues while preparing estimation.

4.4.2.1.2 Data Collection and Management

The input data required for cost estimation include cost data of material, labor and equipment and work crew and productivity. The following sections elaborates the findings of the research.

- **Material Cost Data**

The case contractors have similar practice of material cost data collection. Material prices are collected from local market at the time of bid and when new quotation are prepared for additional works. In addition to this, the study shows that case three contractor have the practice of using quotes from foreign suppliers where the costs are collected through mail and fax communication.

In reference to this, it is observed that material items for civil, finishing, sanitary and electrical work items are widely collected by case contractors at every bid. However, as of case three contractor, the civil work items are not collected for every bid. In addition to this mechanical and data works for lump sum projects (Project A, C and D), are outsourced for special subcontractor and thus cost data are completed by subcontractors.

Regarding the data recording and management system, the contractors have similar practice. The case contractors record the cost data in excel format. However, all cost data collected at the time of estimates are not consistently recorded for future reference.

- **Labor cost data**

The labor cost data collected from project location area and labor subcontractors offer are commonly used in estimation. In addition, the contractors use the direct market rate without adding the labor index factor. The study also revealed that case contractors do not have consistent recording of labor costs.

- **Equipment cost data**

Case one, case two and case three contractors use the market rental rate to fix the equipment hourly cost. However, case three contractor prepare the equipment hourly cost for owned equipment and use the market rental rate foe rented equipment. Similar to the previous discussed, case contractors do not have consistent recording of equipment cost data.

- **Historical data**

The practice contractors regarding historical records are similar. They do not have a system to follow and record such information. In addition to this the contractors use previously established breakdown and estimators' assumptions on the formation of crew and productivity.

4.4.2.2 Cost Analysis

4.4.2.2.1 Pricing Direct Costs

The direct cost involves material cost, labor cost and equipment cost that directly linked with construction activities and the finding of the research demonstrated in the following section as how the case companies applied during cost estimation.

- **Material cost**

The direct material cost analysis of the observed the contractors experience show minor technical differences among the reviewed projects. As discussed previously, case two and case four contractors used quotations without adjusting for future market fluctuations. On the contrary, case one and case three contractor considered market fluctuations on certain finishing, sanitary and electrical materials. In this regard, case one contractor used increased profit margin on the final cost while case three contractor forecasted the increase in material cost by certain percentage the material price. Consequently, the material costs for case three contractor is not an initial value of the quotation.

In addition to material unit price, the material direct cost analysis includes transportation costs, loading, unloading costs, storage, and handling cost for locally purchased materials. In this regard, as previously discussed, case one contractor considered transport costs for cement, sand, aggregate and reinforcement bar. In the same manner, case two contractor used 2%-5% of the material cost for transportation and handling cost, though the values of the percentage are based

on estimators' assumption. In both contractors, loading and unloading costs were not considered.

When we come to case three contractor, the material cost analysis has different approaches for each contract type. For lump sum contracts as the material quantification, and pricing for electrical, plumbing, mechanical and data infrastructure works were outsourced to specialist sub-contractors the contractor does not make direct cost analysis for this case.

However, for admeasurement contracts, the analysis of material costs follow the same procedure as discussed for other contractors. Accordingly, analysis of costs for locally available materials include material price before VAT, transportation expense to site and loading and unloading expense, though the latter three costs are not consistently included. Where as in case of imported material, the material cost analysis include relevant inputs for calculation of import expenses are included.

In case four contractor, in calculating the material direct costs, only the material prices before VAT are considered.

- **Labor cost**

In the analysis of direct labor direct, the labor price collected from market used without indexing it for case contractors. In addition, case three contractor refer to the ongoing projects labor contract rates as an indexed labor cost for concrete, reinforcement, carpentry, block work, plastering and roofing work to labor subcontracted.

In addition to this, for the case projects observed, the number and set up of crew in the break down is the same, which shows that regardless of the quantity of work and the methodology followed to complete the project, there is the same crew arrangement in the breakdown. The crew productivity is mostly established from the estimators own assumptions from their experience.

- **Equipment cost**

The analysis of direct equipment for case contractors show that the market rental rate for equipment used in calculating the direct cost of equipment. However, for owned equipment,

only case three contractor establishes the hourly cost of equipment by calculating the equipment owner ship and equipment operation and maintenance cost.

4.4.2.2.2 Pricing Indirect Costs

In determination of indirect cost, the contractors (case two, case three and case four), allowances made based on the subjective decision of the estimators and management.

The contractors consider profit margin along with indirect cost. In the observed cost breakdowns of the case projects, 25%-35% of the direct cost used as overhead and profit margin. However, case one contractor developed a base line overhead cost from a sample project. According to this sample project, the calculated site OH cost items include project staff costs, project office running expenses, transportation expenses, mobilization/demobilization costs, and financial costs associated with bonds, guaranties, insurance considered.

4.4.2.2.3 Pricing Risks

The contractors experience for risk identification and allowance show that, contractors of case one and case three consider economical risks in their pricing. On the other hand, that case two and case three contractors did not consider the effects of risk in their pricing.

In the study indicated that risk allowance is the most difficult item to estimate and to incorporate in cost. In addition to this, the contractors fail to identify potential risks and forecast the effects during estimating. The contractors also admit that they lack established historical data, time and expertise to make appropriate assessment of documents. On top of this, the contractors absorb some risks in order to stay competitive in market.

4.4.2.2.4 Pricing Profit

The contractors combined overhead and profit margin. Profit margin are determined based on subjective decision.

In general, based on the suggested practices in literature review and previous discussions, Table 4:17 below shows that the major challenge problem areas.

Table 4:17 Problem and challenge areas of cost estimation practice

	Problem and challenge areas	Problems	Case one	Case two	Case three	Case four
1	Assessment of preliminary items					
1.1	Supporting documents	-information from supporting documents not incorporated in cost estimation	In all projects	In all projects	In all projects	- In all projects
1.2	Site visit	information from site visit not incorporated in cost estimation	In all projects	In all projects	In all projects	- In all projects
1.3	Assessment of tender documents	Insufficient tender document analysis	In all projects	In all projects	In all projects	- In all projects

Table 4:17 Problem and challenge areas of cost estimation practice contd.

	Problem and challenge areas	Problems	Case one	Case two	Case three	Case four
2	Information on input data					
2.1	Direct cost components	-not all cost components are collected	In all projects	In all projects	In all projects	- In all projects
		-inaccurate cost data are used	In all projects	In all projects	In all projects	- In all projects
		Lack of actual costs feedback	In all projects	In all projects	In all projects	- In all projects
2.2	Productivity data	-inaccurate production data used in estimating	In all projects	In all projects	In all projects	- In all projects
		-lack of historical data	In all projects	In all projects	In all projects	- In all projects
		Poor project cost feedback	“	“	“	“

Table 4:17 Problem and challenge areas of cost estimation practice contd.

	Problem and challenge areas	Problems	Case one	Case two	Case three	Case four
3	Analysis of direct cost					
3.1	Analysis of material cost	Contractors did not consistently include-material cost elements like transportation +loading and unloading and storage	In all projects	In all projects	In local material cost analysis Considered in imported material analysis are	In all projects
3.2	Analysis of labor cost	The contractors do not make analysis of labor cost. They rely on commercial data.	In all projects	In all projects	In all projects	In all projects
3.3	Analysis of equipment cost	The contractors do not make analysis of equipment costs. They rely on commercials data	In all projects	In all projects	In case of equipment not owned by contractor.	In all projects

Table 4:17 Problem and challenge areas of cost estimation practice contd.

	Problem and challenge areas	Problems	Case one	Case two	Case three	Case four
3	Analysis of direct cost					
3.4	Sub contracted costs -For labor only	Move from analytical estimating to commercial estimating	For all projects	For all projects	For all projects	For all projects
3.5	Sub contracted costs For labor +material	Poor understanding of how specialist trades are costed	"	"	"	"
4	Analysis of indirect cost					
4.1	Head office Overhead cost	Analysis not done	Base line analysis done	For all projects	For all projects	For all projects
4.2	Project overhead cost	Analysis not done	"	"	"	"

Table 4:17 Problem and challenge areas of cost estimation practice contd.

	Problem and challenge areas	Problems	Case one	Case two	Case three	Case four
5	Analysis of risk					
5.1	Identification of risk	Risks are not properly identified	Some Economical Risks identified based on experience	None identified	Some Economical Risks identified based on experience	None identified
5.2	Techniques of risk analysis	Do not have techniques of risk analysis	Risks are considered by increasing profit margin	None used	By forecasting the increase in price of material based on estimator assumption	None used
6	Determination of profit margin					
		Profit margins are not properly calculated, they are mixed with overhead costs	For all projects	For all projects	For all projects	For all projects

4.4.2.3 Out Put of Cost Estimates- How accurate are the cost estimates?

Accuracy is defined as the degree to which a measurement or calculation deviates from its actual price; therefore, estimating accuracy is indicative of the degree to which the final price outcome of a project may vary from the single point value used as the estimated cost of the project. This, essentially, is what every estimator in the industry is after: accurate estimates, which are close to the end result figure. However, from the literature, the accuracy of estimating is influenced by direct or indirect factors, which may push them off the targeted budget.

After examining the current cost estimation practice of the contractors, this research intends to answer the question 'How accurately do contractors predict actual construction costs?'
To answer this, the research attempted to conduct document analysis of the case study company's construction cost records that comprise a comparative feedback of the estimated costs from preconstruction to the actual construction costs. However, the researcher could not find recorded data that shows the actual construction costs.

The experience by case one, two and four contractors show that, they track the executed work volumes and the monthly expenses of direct costs (labor, material, equipment and subcontractor) and some indirect costs (expenses at project site) on project site. However, these data are collected to monitor the performance of the project on monthly bases. Thus, this research was not able to evaluate the deviation of cost estimate from the actual cost.

4.5 Conclusion

This section examined the practice of the cost estimation by the selected case contractors from initial preliminary project assessment up to evaluation of final cost estimate.
In preparing tender estimate, the contractors' practice of the project assessment was evaluated on their practice of evaluating project specifics from supporting documents, site visit, tender document and construction methodology. Following this, the contractors' practice on cost input collection and management were examined. Then the cost components technical analysis was reviewed by comparing with the principles set in the theories and literatures. Finally, the thematic analysis among contractors discussed.

The next section presents the summary of the major findings of the study and provides recommendation on the improvement of the practice.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This study aimed at exploring the current cost estimating practice to identify the major challenge and problem areas faced by the case contractors and to recommend suggestions for improved cost estimating practice.

The research has examined the cost estimation practice of five selected projects from each case contractor. The case study conducted by collecting the case companies' cost records, contract documents and bill of quantities used in estimation of the selected projects. The analysis process also incorporated interviews and discussions to substantiate as well as support the findings of the document analysis to ensure the validity and reliability of the information.

The research shows that contractors use detail-estimating technique to tender price and to quote for variation works.

The cost estimates prepared for pricing the case projects examined from preliminary project assessment to the final the cost estimate analysis.

The preliminary project assessment includes examining how contractors investigate the project specifics from supporting documents, site visit, contract documents and construction methodology. Accordingly, the following are the major findings of the study:

- Supporting documents were not fully provided for contractors at tender stage. It was reported that geotechnical reports were not issued for all projects under study. However, drawings were issued for most of the case projects. The case contractors indicated that they face shortage of time to study drawings .But at some points they indicated referring drawings to understand the details specified in the bill of quantity and to cross check quantities. However, it was reported that there were times case contractors find ambiguity between drawings and BOQ specification.
- Findings of the site visit include the existence of difficult underground conditions, structures that need to be demolished and inadequate space for material damping and storage. However, it was reported that case contractors who attempted to consider the cost associates did not conduct proper cost analysis. On the other hand, there were case contractors who did not consider the costs incurred.

- Contractors' experience of analyzing costs due to contract clauses were studied. In this regard, the clauses related to price adjustment, payment, variation, project duration and risks were studied. It appears two of the case contractors do not properly analyze the costs while the remaining case contractors do not attempt to incorporate these costs at all.
- Contractors do not refer the work methodology in preparing cost estimate.

In the same manner, the project cost inputs were reviewed for data collection and management process. Accordingly, the study on this section reported that

- Case contractors have similar practice of cost data collection and keeping record of it. However, the study revealed that case contractors did not have consistent data records.
- Case contractors collect material cost data from local contractors and only one contractor uses quotes of foreign suppliers. Similarly labor and equipment cost data collected from local market for all cases.
- In addition to this, historical data records on previous projects performance were not recorded and did not have a system to follow such information. In the same manner, contractors use previously established breakdown and estimators' assumptions on the formation of crew and productivity.

The study also examined the contractors practice on the analysis techniques of cost components. In this regard, the following are the major findings of the study:

- Direct material prices are used without proper adjustment of future market for two case contractors while the other case contractors do not consider adjusting at all
- Expenses related to material cost purchased local market are not consistently included in material cost analysis by case contractors.
- The labor cost data from local market are commonly used in estimation. Contractors use the market rate without including the labor index factor.
- Case contractors use the market rental rate to fix the equipment hourly cost. However, only case three contractor prepare the equipment hourly cost for owned equipment

- Three case contractors determine indirect cost based on the subjective decision of the estimator and management. It is observed these contractors use 25%-35% of the direct cost as overhead and profit margin. However, one case contractor has developed analysis for overhead cost. It was pointed that the overhead cost analysis by the contractor showed some technical discrepancies.
- The study indicated that risk allowance is the most difficult item to estimate and to incorporate in cost. In addition to this, the contractors fail to identify potential risks and forecast the effects during estimating. The contractors also admit that they lack established of historical data, time and expertise to make appropriate assessment of documents. On top of this, the contractors absorb some risks in order to stay competitive in market.

Finally, after reviewing the current cost estimation practice of the contractors, this research intends to answer the question 'How accurately do contractors predict actual construction costs?'

To answer this, the research tried to conduct document analysis of the case study company's construction cost records to comprise a comparative feedback of the estimated costs from preconstruction to the actual construction costs. However, this research could not find recorded data that shows the actual construction costs. Thus, this research was not able to evaluate the deviation of cost estimate from the actual cost.

5.2 Recommendation

The study shows the practice mainly challenged by insufficient project information, poor project specifics assessment, poor analysis of construction costs especially in estimating risk and indirect costs and influence of fierce competition in the industry. In this regard, this research recommends the following specific actions to be undertaken by contractors:

- Contractors should introduce guidelines and check lists that fully engage estimators to make appropriate preliminary assessments prior to estimating. Moreover, contractors should develop more specific "how to" guidance in the form of procedures in some critical areas such as potential risk assessment and analysis.
- Contractors should be able to devise ways to follow site performances so that productivity and crew standards are accurately determined. In this regard, formal communication and reports of site feedback should be established.

  In line with the above recommendation, Ministry of Construction and related professional associations should take their share in creating industry benchmarks and should devise ways of updating the information on continual basis.
- Estimates shall develop their knowledge in reviewing project risks and uncertainties that should be incorporated into estimates. In this regard, estimators shall record estimate basis, assumptions and back up calculations for future references. In addition, contractors' management should coordinate trainings that improve estimators' skills and expertise.

  In line with the above, the Central Statistics Agency shall give due focus to prepare refined monthly consumer price index on construction materials, labor and equipment**.** In the same manner, regulatory bodies and related professional associates should work together to improve the compensation system in which a wider range of inputs will be allowed for compensation.
- Contractors shall follow and record actual costs of ongoing projects. This way they can follow on the accuracy of their estimate and develop feedback for future estimates
- In line with the above recommendations, it is highly recommended that contractors establish research and development department to handle the responsibility.
- Contractors shall perform estimate reviews to confirm estimates are accurate and fully reflect project scope.

- Contractors should employ decision supporting estimation tools in addition to the standard method in use. For instance, range estimating can assist in providing probability of cost overrun and assist the risk analysis. Also use of appropriate parametric estimation can help contractors in decision making at earlier stage and can assist in verifying the accuracy of detailed estimates. In addition, contractors can make use of standard estimating soft wares to as they can assist them improving the speed and reliability of estimates.

5.3 Future Research

This study tried to review some of the challenges associated with cost estimation practice of local case contractors. However, the researcher believes that further work on the area is vital to guide the efficient improvement in the area.

- Study of methodologies to integrate construction risks in cost estimation
- Study of level of accuracy of cost estimates among different grades of contractors
- Study alternative methods of cost estimation that improve accuracy of cost estimates
- Study on building cost drivers and indicators
- Study on construction estimating software and data base management system

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APPENDIX

Appendix A- Interviews

The following interview questions were prepared for further discussion and clarification on the cost estimation practice of the case contractors.

I. Questions on General Company Level Cost Estimation Practice

1. Does the company have standard estimating format or base estimate? How often is it updated?

	Case contractors	Answers by case contractors
1	Case one	We have prepared excel estimating format, we don't have scheduled updating time. We just prepare bid estimates using it as base estimate
2	Case two	Same as above
3	Case three	"
4	Case four	Yes we have format, we update it once a year on average

2. Does your company have practice of using estimating software?

   -All cases do not have the experience of using estimating software

3. In your detailed estimating practice, are the costs of labor, equipment and material tracked separately?

   - All cases replied they keep records of the collected costs of labor, material and equipment in excel format

4. Does your company have data base systems for:

item	Description	Case -1	Case -2	Case -3	Case - 4
a	For cost information on material cost	yes	yes	yes	yes
b	For cost information on base labor cost	yes	yes	yes	yes
c	Labor index estimating	no	no	no	no
d	Equipment rental cost adjusted by the company	no	no	yes	no
e	Equipment rental cost as per market	yes	yes	yes	yes
f	For material consumption rate	no	no	no	no
g	For labor productivity	no	no	no	no
h	For equipment productivity	no	no	no	no
i	For crew formation and productivity	no	no	no	no
j	historical data base for existence of the risks	no	no	no	no
k	overhead cost	yes	no	no	no
l	markup cost	no	no	no	no
m	For work breakdown structure	no	no	no	no
n	if other, mention	no	no	no	no

5. How does your company incorporate subcontractors offer to fix the price?

	Case contractors	Answers by case contractors
1	Case one	by directly taking the previous offer as direct cost and forecast the cost then include the company's indirect cost
2	Case two	Same as above
3	Case three	"
4	Case four	"

6. Does your company incorporate risks in cost estimation?

	Case contractors	Answers by case contractors
1	Case one	We consider risk for price change
2	Case two	No in case of competitive bids
3	Case three	We consider risk for price change for the materials we import
4	Case four	No in case of competitive bids

7. Who is involved in the process of pricing for risk?

	Case contractors	Answers by case contractors
1	Case one	the management is possible for determining the percentage to of risk,
2	Case two	
3	Case three	the engineering head is ultimately responsible for determining the price of risk, which usually occurs during a tender review
4	Case four	

8. How do you calculate the amount to include for risk in your tenders?

	Case contractors	Answers by case contractors
1	Case one	We don't have technical calculation, we just increase our profit by percentage
2	Case two	
3	Case three	We price risk on a trade by trade basis as we receive subcontractor and supplier prices … We assess the suitability of the prices we receive and determine how much it should cost to do the work … We need to look at each area of the work in isolation to assess our risk and make adjustments accordingly…
4	Case four	

9. What are the risk identification techniques in use by your company to determine its cost implications in your company?

	Case contractors	Answers by case contractors
1	Case one	Experience and assumptions
2	Case two	
3	Case three	Experience and assumptions
4	Case four	

10. What are the challenges and draw backs of the current practice in tracking and managing of historical data base ?

	Case contractors	Answers by case contractors
1	Case one	Lack of efficient controlling system
2	Case two	Lack of time and coordination
3	Case three	System not developed
4	Case four	Efficiency of data collectors and absence of organized data base system development

Appendix B- Cost analysis templets

Appendix B-1 Cost analysis for imported item, case three contractor

(A) COST OF IMPORT, CUSTOMS DUTIES, TAXES, ETC

1 RELEVANT DATA

1.1	**Description of Items being Imported:**	Fire Rated Doors - Size 1150x2100mm (from Ase Europe)							
1.2	Currency of Import =	€	→ Assumed Exchange Rate =	€ 1.00	=	ETB 25.00			
	→ Resulting Exchange Rate, after including Bank Charges at	6.50%	=	ETB 26.63					
1.3	FOB Value of Commercial Inv. =	€ 58,000.00	→	ADH Price +€300					
1.4	(a) Quantity being Imported =	29.0 pcs	(b) HS Code for Commodity :	7308.3000					
1.5	No of Containers for Consignment →	0 x 20' Container(s)	+	1 x 40' Container(s)					
1.6	Port of Loading of Containers:	Antwerp	→						
1.7	Est'd Cost of Sea Freight:	Antwerp	to	Modjo Port					
				Sea Freight	+	Inland Transport			
	1.7.1 For 1 x 20' Container =			€ 1,600.00	+	ETB 60,000.00	=	€	3,853.52
	1.7.2 For 1 x 40' Container =			€ 2,200.00	+	ETB 90,000.00	=	€	5,580.28
1.8	Estimated Cost of Marine Insurance =			ETB 6,000.00	=	€ 225.35			
1.9	"Transiting" Company's Charges for Clearing from Modjo Dry Port and transporting to Addis Abeba:								
	1.9.1 For 1 x 20' Container =			ETB 15,000.00	=	€ 563.38			
	1.9.2 For 1 x 40' Container =			ETB 25,000.00	=	€ 938.97			
1.10	Cost of Unloading/Unstuffing →	1 x 20' =	ETB 3,000.00	;	1 x 40' =	ETB 5,000.00			
1.11	Customs Duties, Taxes, Etc. for given HS Code are as follows:								
	1.11.1 Customs Duty =	10%	1.11.2 Excise Tax =	0%	1.11.3 VAT =	15%			
	1.11.3 Sur Tax =	10%	1.11.4 Withholding Tax =	3%					

2 COST CALCULATIONS

2.1	Total FOB Cost =	€	58,000.00	= ETB	1,544,230.00	
2.2	Cost of Sea Freight and Inland Transport =	€	5,580.28	= ETB	148,575.00	
2.3	Cost of Marine Insurance =	€	225.35	= ETB	6,000.00	
2.4	Total Cost (CIF) =	€	63,805.63	= ETB	1,698,805.00	
2.5	Customs Duties, Excise Tax, VAT, Sur Tax, and Withholding Tax Calculations:					
	2.5.1 Customs Duty = 10% =	€	6,380.56	= ETB	169,882.50	
	2.5.2 Excise Tax = 0% =	€	0.00	= ETB	-	
	2.5.3 VAT = 15% =	€	10,527.93	= ETB	280,306.13	
	2.5.4 Sur Tax = 10% =	€	8,071.41	= ETB	214,901.36	
	2.5.5 Withholding Tax = 3% =	€	1,914.17	= ETB	50,964.75	
	[2.5.6 Total Payable to Customs =	€	26,894.07	= ETB	716,054.74	]
	[2.5.7 Amount to be Considered as Cost = *	€	14,451.98	= ETB	384,783.86	]
	*the VAT and Withholding Tax Amounts are not considered as "Cost".					
2.6	Estimated Clearing and Transport Charges for:					
	0 x 20' Container(s) + 1 x 40' Container(s) =	€	938.97	= ETB	25,000.00	
2.7	Estimated Cost of Unloading for:					
	0 x 20' Container(s) + 1 x 40' Container(s) =	€	187.79	= ETB	5,000.00	
2.8	Total COST OF CONSIGNMENT (Delivered to	€ 79,384.37	= ETB	2,113,608.86		
2.9	COST of IMPORTED ITEM(S) per UNIT =	€ 2,737.39	= ETB	72,883.06	per pcs	

(B) COSTS OF INSTALLATION				
3.1	**Cost of Materials Required for Installatoin**			
3.1.1	Fixing Accessories - 10 x Anchor Bolts @ Br250/pc	ETB	2,500.00	/ pcs
3.1.2	Scaffolding, and civil works	ETB	600.00	/ pcs
3.1.3				/ pcs
3.1.4				/ pcs
3.1.5				/ pcs
		ETB	**3,100.00**	**/ pcs**
3.2	**Labour/Personnel Costs**			
3.2.1	Installation Costs by Subcontractor	ETB	2,000.00	/ pcs
3.2.2				/ pcs
3.2.3				/ pcs
3.2.4				/ pcs
3.2.5				/ pcs
		ETB	**2,000.00**	**/ pcs**
3.3	**Σ INSTALLATION COSTS =**	**ETB**	**5,100.00**	**/ pcs**

(C) TOTAL COSTS (SUPPLY AND INSTALLATION), INCL. OHP						
4.1	Total **COST OF PURCHASE** (from [2.9]) =	€	2,737.39	=	ETB	72,883.06 / pcs
4.2	Total **COST OF INSTALLATION** (from [3.3]) =	€	204.00	=	ETB	5,100.00 / pcs
4.3	**Σ COST of SUPPLY and INSTALLATION =**	**€**	**2,941.39**	**=**	**ETB**	**77,983.06** / pcs
4.4	**Add 40.0% OHP =**	€	1,176.56	=	ETB	31,193.23 / pcs
4.5	**Σ SUPPLY + INSTALLATION + OHP * =**	**€**	**4,117.95**	**=**	**ETB**	**109,176.29 / pcs**

*** Excluding VAT**

(D) EXCLUSIONS, COMMENTS, CLARIFICATIONS, ETC	
5.1	
5.2	
5.3	
5.4	
5.5	
5.6	

Appendix B-2Sample Equipment direct cost analysis, case three contractor

		Rated	HP	Equipment	Equipment		Salvage	Tyre					Depriciation		Insurance			Repair Cost		Fuel Consumption				Service Cost		Tyre Cost	Owning	Operating	O & O
		Capacity		Delivery	Life time		Value (birr)			price	Price	Life	Cost (birr/hr)	Interest	Rate	Cost			Factor	(D*T)	Cost		Birr/h	Birr/hr	Cost	Cost	Cost
				price	(Hours)	(Yrs)	10%E	Size	Q'ty	(birr)	(Birr)	Hour	= (E-L-H)/F	(Birr/h)	%	(E*P/100)*0.05	%N	Birr/hr	Lt/h/Hp	Lit/h	FuelCost	%V	(x)	(y)	(N+O+Q)	(S+V+X+Y)	(Z+_AA)
Item	Equipment Type			(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	r	(s)	(t)	(u)	(v)	(w)	(y*w)	= L/M	Birr/hr	Birr/hr	Birr/hr
1	Dump Truck 6x4	12-14 m3	300	1,020,000	12,000	6.0	102,000	11x20,12x20	10	2,424	24,240	1,500	74.48	13.07	2.20	11.22	20	14.90	0.10	30.00	536.70	20.0	107.34	16.16	98.77	675.10	773.87
2	Excavator, wheel type	1.0 - 1.5 m3	150	3,600,000	12,000	6.0	360,000	15.5x25	4	4,500	18,000	2,500	268.50	25.75	1.20	21.60	200	537.00	0.15	22.50	402.53	25.0	100.63	7.20	315.85	1047.36	1,363.21
3	Vibrtatory plate compactor(8500kg)		13	250,000	12,000	6.0	25,000						18.75	19.63	1.20	1.50	70	13.13	0.20	2.60	51.66	20.0	10.33	0.00	39.88	75.12	115.00
4	Jack Hammer			800,000	6,000	3.0	80,000						120.00	0.41	1.20	4.80	50	60.00	0.00	0.00	0.00	10.0	0.39		125.21	60.39	185.60
5	Loader, Wheel	2.0 - 2.5 m3	200	1,434,000	10,000	5.0	143,400	23.5x25	4	5,600	22,400	2,200	126.82	19.93	1.20	8.60	60	76.09	0.14	28.00	500.92	25.0	125.23	10.18	155.35	712.42	867.78
6	Concrete Mixer, trailer mounted	500 lit	25	170,000	16,000	8.0	17,000	6.5x16	2	550	1,100	2,500	9.49	2.95	0.40	0.34	50	4.75	0.14	3.50	62.62	14.0	8.77	0.44	12.78	76.57	300.00
7	Crawler Dozer	140 - 180 Hp	160	8,885,500	13,000	6.5	888,550				0		615.15	34.14	1.20	53.31	275	1691.66	0.14	22.40	400.74	30.0	120.22		702.60	2212.62	2,915.22
8	Concrete Vibrator, petrol	4Hp	4	15,940	8,000	4.0	1,594				0	0	1.79	0.25	0.40	0.03	50	0.90	0.14	0.56	11.13	7.0	0.78		2.08	12.80	50.00
9	Mobile crane																		0.14								960
10	Polishing mach.																		0.14								250
11	Welder, Electric	300 - 400 AMP	-	101,020	8,000	4.0	10,102						11.36	1.58	0.40	0.20	30	3.41	0.14	0.00		0.0	1.00	0.00	13.15	4.41	17.56
12	Hand Compactor																										0.00
13	Asphalt Distributor	6000 lts	200	3,076,317	14,000	7.0	307,632	11x20,12x20	6	1,924	11,544	2,200	196.94	17.67	2.20	33.84	350	689.29	0.14	28.00	500.92	25.0	125.23	5.25	248.45	1320.68	1,569.13
14	Water Truck	6000 lts	150	1,488,570	12,000	6.0	148,857	11x20,12x20	6	1,924	11,544	1,800	110.68	7.87	2.20	16.37	150	166.02	0.10	15.00	298.05	20.0	59.61	6.41	134.93	530.09	665.02
15	Power Broom self propelled	1 - 2 m	70	1,628,930	11,000	5.5	162,893	11.2x20	4	2,100	8,400	2,200	132.51	10.09	0.40	3.26	80	106.01	0.10	7.00	125.23	22.0	27.55	3.82	145.86	262.61	408.47
16	Spreader, aggregate	5 - 7 m	170	3,254,250	15,000	7.5	325,425	10x20	4	1,800	7,200	2,200	194.78	20.75	0.40	6.51	80	155.82	0.14	23.80	425.78	30.0	127.73	3.27	222.03	712.61	934.64
17	Roller, Pneumatic	About 10 ton	100	2,713,855	15,000	7.5	271,386	11x20	7	1,700	11,900	2,500	162.04	11.81	1.20	16.28	80	129.63	0.14	14.00	250.46	30.0	75.14	4.76	190.13	459.99	650.12
18	Roller, Vibrator, 2 drums	10 - 16 ton	150	2,213,830	12,000	6.0	221,383						166.04	19.63	1.20	13.28	80	132.83	0.20	30.00	536.70	30.0	161.01	0.00	198.95	830.54	1,029.49